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LECTURE.

Friday, June 13th.

COLONEL THE RIGHT HON. LORD WAVENEY, F.R.S., A.D.C. to the Queen, in the Chair.

ON "THE EASTERN CAUCASUS AND DAGHESTAN."

By Lieut.-General Sir ARTHUR CUNYNGHAME, K.C.B. Colonel, 36th Regiment.

SURROUNDED as I find myself by so many persons of consideration and intelligence, and by Officers of distinction, I own it is not without feelings of some apprehension that I deliver this rough recital of my experiences during my last trip in Asia.

The merit, if any, which I lay claim to, is that of having undertaken this journey in a country where few Englishmen have preceded me, and therefore freshness and novelty may give it some interest.

The general features of our expedition comprised a run through Europe to Constantinople, Southern Russia, and the Crimea, the Cis- and the Trans-Caucasus, with a return home by the southern shores of the Black Sea. I propose mostly to dwell upon those places less known, such as Daghestan, &c.

On the 9th of June, we landed at Antwerp, and proceeded thence *viâ* Brussels, Aix-la-Chapelle, Cologne, and Munich, to Vienna. We here took advantage of the opportunities which were placed in our way, by His Excellency Lord Blomfield, of seeing as much as possible of the military establishments of Austria, and it is satisfactory for me to think, especially after a recent visit to Woolwich, that we have very little to learn as to military science from that country.

Leaving the interesting and beautiful city of Vienna, we next visited Pesth, where, since its emancipation, giant strides of improvement are everywhere evident. Pesth bids fair to become one of the handsomest, largest, and most thriving cities in Europe.

Passing through Temesvar, we embarked at Basiach, on the Danube, and threading the Carpathian mountains, in two days reached Giurgevo. Here we struck north to Bucharest, a city covering as much ground-space as Paris, but so little known in the west.

Returning by Rustschuk, we proceeded to Schumla, where Ali-Kerim-Pacha presented me to his army corps. Many years since I had commanded a division of the Sultan's troops, and it is with the greatest

interest that I can bear testimony to their general improvement in appearance, physique, activity, and the cleanliness of their camp.

Leaving Schumla, we reached Varna. The last time I saw this roadstead, now nearly deserted, it had contained between 500 and 600 ships, the fleet destined to attack Sebastopol. Leaving Varna, we landed at Constantinople. There are so many here present well acquainted with this beautiful city, and who could describe it better than myself, that I will only remark, that the rapid strides which are being made in the improvement of the city, make me think that ere long, it will equal in cleanliness, as it now surpasses in beauty, almost any city in Europe; the development of its naval and military organization is, moreover, surprising to those who, like myself, knew it nearly 40 years ago.

At this stage of our journey, a stronger interest surrounded us, as much, if not all that I saw, with the exception perhaps of the Crimea, was new to myself, as it would be to other Englishmen.

Leaving Constantinople in a fine vessel, nominally a trading steamer, we started for Odessa. I may mention that these Russian trading steamers are officered by the Imperial Navy, thus keeping her naval Officers in training, and giving those that are energetic, the advantages of considerable extra pay and allowances.

On leaving the Bosphorus, the Russian Consul-General presented me, by order of the Russian Ambassador, with letters for the authorities in Southern Russia and the Caucasus; these we found of the utmost advantage in our subsequent journey.

I may here mention that we were generally informed that the journey we proposed to take in Daghestan, we could never accomplish—that we should be lost in the mountains. I own that it was not without some misgivings on the subject that we determined to proceed.

On the third day, we landed at Odessa, where, no sooner was it known that I was an English General Officer, than every Custom-house formality was immediately dispensed with, and every attention was shown me. Odessa is a cold, bleak, and comparatively new commercial city; its great industry being that of shipping corn for England. The inventions for sifting and airing grain are far behind those in use in America, no steam machinery existing for this purpose; but as fine quays have been erected at a large expense, vessels of 3,000 tons can easily lie close to the piers.

We were naturally very desirous of visiting Nicolaief, that Russian arsenal which is creating so much interest in England.

We left Odessa at 12 p.m., and early on the following morning, passing the Kinburn Spit, we entered the River Bug. The channel was represented to be about 21 feet deep, the bottom soft mud. The river narrowed gradually as we approached Nicolaief. About seven miles below that city we passed three powerful forts, one on an island in the centre of the river, and one on either bank; these were armed with heavy Krupp guns. We disembarked near the junction of the Bug with the River Ingul, the arsenal being quite hid from our view by the range of hills upon which the town stands. Subsequently we had a good opportunity of seeing the arsenal itself.

Yesterday's *Times* gave an account of the launch of an ironclad of 480 horse-power, "The Novgorod;" it may therefore be considered very bold of me to state that, I cannot yet look upon Nicolaief as an iron-clad constructing arsenal. How this vessel has been constructed I can only surmise; her plates may have been brought by sea from Western Europe, or may have been sent by rail from St. Petersburgh; but I can scarcely believe that they were rolled in a genuine way in Nicolaief itself; and without a large command of iron and coal on or near the Black Sea, it is almost an insurmountable task for Russia to construct a really powerful ironclad steam fleet such as would endanger Constantinople.

We may look at the difficulties and immense expense in iron ship-building which, with all our advantages, are entailed upon us; we have skilled workmen, iron in close proximity with coal, for years a gradual progressive knowledge of this art; and, yet by what enormous energy alone are we enabled to surmount them. There may be coal and iron on the River Don, but as yet, this industry is in such a state of infantine development, that the rolling of such huge plates as form the sides of the "Devastation," is altogether out of the question; and what I saw in the arsenal on the Ingul, gave me the impression that some of our large mercantile ship-building establishments could far surpass it.

When we remember, moreover, the magnificent ironclad steam fleet now dotting the Bosphorus, under the walls of the Seraglio, it is futile to imagine that the Russians can for many years to come, produce such a vessel on the shores of the Black Sea as could exist under the fire of such monsters as the Sultan has collected for the defence of his Empire. Nor can I for a moment believe that the Turks could be so infatuated as to sanction the passage through the Dardanelles or the Bosphorus of any such vessels as would be likely to be injurious to them. My belief is, that it must be a very long time ere such a fleet could be constructed on the Ingul, as would cause us or our friend the Turk, any great amount of anxiety.

We returned in a crowded vessel to Odessa, but such was the kindness of the Captain (an Officer of the Imperial Navy), that, himself sleeping on deck, he relinquished his cabin to us.

On the following day, we embarked for the Crimea, touching at Eupatoria, which, on my last visit, was threatened by the grand fleet of 600 ships, when we attacked Russia.

In the afternoon, we reached Sebastopol, the desolation of which, was more remarkable than when I had left it, on the breaking up of the grand army in 1855. From 80,000 inhabitants, Sebastopol has now dwindled down to 8,000.

It is contemplated by many that Sebastopol will become a grand mercantile harbour. When the system of railroads from the corn-growing countries to the east, west, and north are finished to this port, its perfect security and depth of water, offering facility for vessels of any tonnage to approach the quays, and thereby preventing a second embarkation of corn, (as is now the case from the Sea of Azof,) a vast saving of expense will be effected, and the city which stood as the menace of

Europe will be converted into one of the largest peaceful mercantile emporiums of the world.

We visited the well-remembered trenches and the battle fields of Inkerman, and saw the spots where many a friend was laid low. The mausoleum erected by the Russians in the shape of an Egyptian pyramid, is solid and handsomely constructed. That, as well as the French cenotaph, has the advantage of gathering together in one spot, if not the actual remains of all those soldiers who died for their country, yet concentrates the recollections of their glorious deeds, whereas the vain attempts to preserve the monuments of our brave countrymen scattered over the wild plains where they fell, are almost impossible of achievement.

We visited Alma and Balaclava and the valley of Inkerman; but it is impossible in the space of this lecture to dwell upon these interesting fields, or upon beautiful "Bagtchi-serai," the burial ground of 80,000 Russian soldiers.

We then embarked for Yalta, and saw the palace of Prince Woronzoff at Aiupka, and the Emperor's palace at Lavadia, and thence proceeded to Kertch.

This fortress has become most interesting. I was astonished at the immense fortification which the Russians have here erected; it is said to be a pet work of Todleben, and to have already cost 22,000,000 of roubles, and for ten years the daily labour of 2,000 men. It appears doubtful to me, however, if any circumstances could arise, whereby this great outlay could meet with commensurate advantage. I had some opportunities of seeing the outer works of the fort, but could not obtain admission into the interior.

Re-embarking at Kertch, we sailed past the fort of "Yenikale," between Europe and Asia; the Strait here is very narrow and easily defensible.

The Sea of Azof is muddy, shallow, and subject to constant storms; we had a deluge of rain, many of the passengers and the Captain were attacked with cholera, and we had a most uncomfortable passage to Taganrog. Here we came upon the great arable plains of Eastern Russia, one farmer possessing 40,000 acres of corn lands in his own hand. It was satisfactory to see the immense number of English agricultural machines which were being imported into that country.

We next embarked on the River Don, and were four days going up that river. We had an opportunity of seeing the Don Cossacks, as fine an irregular force as exists. Their system of service depends upon patriarchal principles, for whilst each in turn is devoting his services to the Emperor, the rest are occupied in cultivating their lands. There are 80,000 Cossacks of the Don, a proportion of artillery as well as cavalry: a large number are always on duty at St. Petersburgh. They are excellent horsemen, active, intelligent, and trustworthy, and their power of enduring either heat or cold, is almost incredible. In the period of time to which this lecture is restricted, it is impossible for me to give an account of the principles upon which the armies of the Cossacks of Russia are regulated.

At length we reached Kalach on the Don, and passed by rail to

Tzaritzin on the Volga. Here it is supposed was an ancient canal, by which the Genoese—those wonderful pioneers of commerce—took their small vessels, and passing from the Mediterranean through the Black Sea by means of the Volga, descended into the Caspian, and formed settlements at the base of the Caucasus mountains, the descendants of whom, although changed in their religion from Christianity to Mahomedism, are still residing in their mountains.

At Tzaritzin, we embarked on the Volga, and had a most uncomfortable passage down the river to Astrakhan.

It was at Astrakhan that Peter the Great first built his naval dockyard on the Caspian; and the boats which he built with his own hands and his basket of workman's tools are still shown. Peter had a sure prescience of the future Eastern conquests which Russia would make. True to Russian policy, the Caspian arsenal has now advanced towards the shores of Persia, to Baku. Near Astrakhan is a large Mongolian Kalmuck settlement, 80,000 of whom inhabit a district on the western bank of the Volga; they are the only Buddists in Europe who worship in Chinese temples, and inhabit Mongolian tents, so ably described by Colonel Yule in his travels of Marco Polo. They drink the brick tea with fermented mare's milk, and resemble the Nomadic tribes which I had seen in the north of China and the Thibetan valleys.

The wealth of the cathedral at Astrakhan is fabulous; pearls and diamonds in profusion being shown to us. Here, there used to be considerable trade with the East, and with India, which latter appears now entirely extinguished.

We now entered the Caspian Sea, the greater part of which is very shallow. It is so stocked with sturgeon, that the value of this fishing is said to be about £2,000,000 sterling per annum; wild ducks are in such profusion that they sell for 1½*d.* each, and pheasants are said to abound on the islands at the 60 mouths of the Volga.

The eastern side of the Caspian is little known; it is inhabited by a warlike race of Kurds. The Russians have established themselves on some isolated points, of which the fort of Krasnovodsk is an example, and it is hence that a column has started for Khiva. On the western side of the sea, are some interesting towns, especially that of Derbend, where an ancient wall partly exists, resembling that of the great wall in China, and also Baku, the seat of the eternal fires, whence, Marco Polo relates, petroleum, for lighting purposes, was carried as a regular industry throughout a large portion of Armenia.

We landed at Petrovsk, and, after some difficulties, struck into the mountains to visit Daghestan and the fighting grounds of the renowned Schamyl.

We were now fairly in the Caucasus; and perhaps this is the proper moment to consider the Russian army which is kept in that division of the empire, and which, to our ideas, seems very large, as the country is not so extensive as either the Bombay or Madras Presidency.

The Russian army in the Caucasus consists of—

Cavalry	3,700
Infantry	131,500
Artillery	8,000
Engineers	2,300
Establishment	5,800
Total	151,300
Steamers on the Caspian	20
,, ,, Aral	4
,, ,, Black Sea	29

The greater portion of the eastern mountain districts, or Daghestan, was only subdued some ten years since; here the renowned Schamyl ruled with determined vigour, resisting for nearly twenty years the mighty monarch of more than 1,200,000 soldiers—a force of at least 120,000 men during all this time being constantly employed—while Schamyl's army never exceeded 20,000 native Circassian warriors. This unexampled feat requires some consideration to render it credible, but shows how an impregnable country, composed of natural fortresses, is able to resist the most determined and skilled armies.

To no small degree was our interest augmented when told by the Russian Generals that only two English travellers had ever previously penetrated into this country. I need not now dwell upon the hardships and difficulties which a journey into these mountains entailed upon us. At length we reached Guinib, the last stronghold of Schamyl. Guinib is a natural fortress, 4,000 feet above the valleys which surround it, but little larger than Gibraltar, its sides, the naturally scarped rock, impossible to ascend. Here great heroism was displayed on either side; at an immense sacrifice of life, the stubborn Russians, under the command of Prince Bariatinsky, obliged the heroic Schamyl to deliver up his sword.

Opposite to Guinib is the country of the Kasi-Kamouks. They are the lineal descendants of the Genoese, to whom I have previously alluded; they are equally skilled in gold and silver work as were their Christian progenitors in Italy; none can now excel them either in London or Paris in their adornment of arms or in jewellery; and it was by these men that the soldiers of Schamyl were provided with their best arms. One of the most remarkable features of that war was, that up to the date of the Crimean campaign, no army of civilised Europe had been universally armed with the rifle, whereas there was no soldier who fought under Schamyl but carried a rifled weapon; this fact alone would account for the wonderful resistance made by that national army.

From Guinib, we passed into Honsak, the command of General Prince Nakashudjee, who repeated all the attention and kindness of General Kamaroff; thence to Bodlith, where General Prince Chaf-cha-vadsey —descended from the Royal Family of Georgia—and General Prince Orbeliani, commanded. Thence we crossed the mountains towards Weden; here, we saw the almost incredible feats performed by the mounted Tartar horsemen, who, although on the edges of pre-

cipices, riding at a furious gallop, stood upon their saddles, fired their muskets beneath the bellies of their horses, or, leaning down, picked up pebbles from the heath. On our road to Weden, we passed that gorge in the mountains where Prince Woronzoff suffered his disastrous defeat.

At Weden, Prince Errinsoff received us with the usual kindness. We were now in the real district of the Cheekengis or Circassians. The men were fine-looking fellows, and the women handsome. Since the conquest of this country by Christian Russia, the purchase of women is almost impossible.

Here again is the seat of those fierce bands of the Amazons who, regardless of all danger, with shirt of mail and casque of steel, fought in the front of the battle, obtaining immense proficiency with the bow and the spear, which they wielded with such dexterity.

Our ride through the mountain was now ended, and henceforward we obtained the posting carts of the country. Remaining a brief time at Vladi-Cavcas, the capital of the Northern Caucasus, we prepared to cross the mountains into Asia.

The first object on our passage through the Pass of Dariel was the magnificent mountain, Kasbek, perpetually covered with snow; it is 1,000 feet higher than Mont Blanc, and it is satisfactory to record that the first person who surmounted the difficulties of the ascent of both Mounts Kasbek and Elbwitz was an Englishman, Mr. Freshfield.

It was at the foot of Kasbek that we met his Imperial Highness the Grand Duke Michael, from whom, subsequently, we received the utmost attention.

We next proceeded to Tiflis, which we reached in the early part of September. It is impossible here to enter upon more than the salient points of our journey, but perhaps you will allow me to speak of the subject of the railway system of these countries, which is creating such an interest in Europe.

A railway is now completed from Poti, on the Black Sea, to Tiflis, and is to be at once proceeded with to Baku, the new arsenal on the Caspian. A rail is projected to connect Taganrog by Stavropol and Derbend, by the shores of the Caspian Sea, to Baku, and from Bakou it is contemplated to extend it to Teheran. It is advocated by many that we should subsidize the scheme which is proposed, of connecting Constantinople by a line running south of Trebisond towards Mount Ararat and Erivan, and thus to Teheran, and that prolonging this line by Herat and Candahar, we should join it at Mooltan, with the railway system of India.

Again, the scheme of Monsieur Lesseps, by which communication between Europe and India should be made *vid* Moscow, Samarkand, and Cabool to Peshawur, and the line of the Euphrates Valley, have lately been brought prominently to our notice.

It cannot be otherwise than with feelings of great respect that we look upon a scheme advocated by so renowned a man as Lesseps, who has united the navies of two worlds; but at the same time, bearing in mind the enormous length of the line which he advocates, and which in its execution would probably require a sum of £50,000,000

sterling, as also the great military objections of being dependent upon the good auspices of Russia for our overland communication with India, I really think we may dismiss this line of communication entirely from our contemplation.

Again, the line through the north of Persia, for almost the same reasons that I have adduced respecting that through Russia, cannot but meet with grave objections. The one would probably equal in expense the other, and would be open to almost the same military objections, as the armies which could readily be brought from Russia by the Caspian from the Volga, and by the line of rail to which I have alluded from Taganrog, would materially frustrate,—should we be at war with that Power,—all endeavours on our part to succour our armies in India through the assistance of a speedy overland route by the north of Persia to that country. I cannot, therefore, but believe that if it is conceded that an overland line of rail should be made to India, the line by the Euphrates valley from Aleppo to Grain, on the Persian Gulf, is the one which it will be most advisable to adopt. No doubt it could not be considered complete until a connection was formed between Aleppo and Constantinople, and also by Bagdad through the south of Persia to Kurrachee (of course I premise that Aleppo has been joined to Alexandretta). But the advantage of the Euphrates line is, that the portion from Alexandretta to Grain being completed, this portion could be at once utilised as the assistant to a speedier transit, and thus, should any unforeseen accident happen to the Suez Canal, we should not be left, as our only alternative route, with that of the Cape of Good Hope.

We were surprised at the size and prosperous appearance of Tiflis, the capital of the Caucasus. In its centre is the palace of the Governor General, the Grand Duke Michael, brother to the Czar, and who receives £70,000 per annum to enable him to keep up the dignity of his position. So little is Tiflis known, or considered, in England, that not even a British Vice-Consul is stationed here.

While at Tiflis we visited Prince Mirsky, who commands an army of about 100,000 men, and Baron Nicolaef. Both were residing at Kadjori, in some mountains above the city, whence a magnificent panorama of the Caucasian range was visible.

The splendour of the view will be understood when I say, that fully half a dozen mountains, each higher than Mont Blanc might be seen rising up at various points.

We then posted south towards Erivan and Mount Ararat, entering some wild arid plains covered with large boulder stones. Even the melon carts had their escorts of armed men, whose muskets were always in readiness.

About half way to Erivan lies Lake Gotcha. There the Armenian monks declare fish can only be caught during Lent.

The appearance of Mount Ararat is sublime. It is nearly 18,000 feet high, and one-third of the mountain is always covered with snow. No person, except, of course, Noah and his family, has ever been to the top. To get there I believe is impossible. The point where the corners

of Russia, Persia, and Turkey in Asia meet, is exactly at the apex of the mountain.

Erivan is a very singular city. The dress and language there are quite in the style of the Arabian nights.

From Erivan we travelled at the base of Mount Ararat, to the Armenian convent of Echmiadzin, not far from the borders of Turkey. It is very ancient, and its manuscripts are 2,500 in number. These are all that remain of a once very large library, which was almost all destroyed in the Persian war. It probably contains a large number of the works of the early fathers, which were mostly written in Armenian. There is also a church with curious architecture, date B.C. 300.

We next proceeded to Sardarabad, and in two days, after much difficulty, reached the town of Alexandrapol. This fort, although almost unknown in Europe, is one of the strongest and largest in Russia, and cost in its erection, no less than 22,000,000 of roubles. It is built to menace Kars, from which it is about seventy miles distant.

We now entered a beautiful district, visiting Akhalkalakik and Akhaltsikh, and passing not far from the mineral spring of Abastuman, visited Borjome, the country seat of the Grand Duke Michael. In his absence, we were received with the utmost kindness by Her Imperial Highness. Thence we posted to the junction of the railway from Tiflis to Poti, passing through the malarious forest of Imeritia.

The vegetation of this district is very remarkable. Vines grow in profuse luxuriance, immense bunches of grapes hanging pendant from the slender branches which entwine themselves round the elm trees of the forest, while cereals flourish abundantly wherever they are sown. The rivers running from the mountains wander through this widely extended forest. These are the far famed streams where Jason sought the golden fleece, and which even to this day are made use of in the same manner to procure this precious metal. The woolly fleeces of the mountain sheep having been immersed in these running waters, the fine gold particles which adhere to them, are carefully picked out.

We had now terminated the arduous portion of our land journey. We had traversed Daghestan almost from end to end, a country scarcely more known in England than by name. We had seen some of the highest mountains in the world, and visited the most beautiful scenery. We travelled in the Caucasus alone 1,340 versts, having ridden a portion of this distance in the crutch-like Tartar saddles of the country, the remaining distance on carts without springs. We had lodged alternately in palaces and pigsties; had eaten alternately luxuries and lived on black bread and stale fish; we had seldom taken off our clothes or slept on other than wooden boards; but all these hardships only enhanced the pleasure with which we had travelled through this almost unknown, interesting, and beautiful country.

The mountains of the Caucasus contain a race of as handsome and sturdy mountaineers as any in the world; the plains are rich with vegetation to a degree scarcely credible, and the mineral rewards which scientific seekers may obtain, are as yet hidden for future research.

The native inhabitants are gentle and phlegmatic; the Russian settlers energetic and very hardy, but rude and uncivilised, the upper

classes hospitable to a stranger to a degree almost incredible; and it was with feelings of gratitude to them, and admiration of this surprising country, that we quitted its shores.

We now embarked once more upon the Black Sea at Poti, the port which the Russians have established for their communications with Odessa, Sebastopol, Nicolaief, and Europe, and whence their railroad commences for Tiflis, their capital, and Baku, their arsenal, on the Caspian. It is most unfortunate for Russia that in place of her last unsuccessful war with Turkey, she had not interested herself to obtain Batoum, which lies about 40 miles to the south of Poti. The bar to the harbour of Poti is extremely dangerous and shallow, whereas Batoum is a natural harbour, which by an extension of the spit of land by a groin or pier, could be made an excellent one.

From Batoum we visited Trebizonde, Karasund, Sinope, and other towns on the southern coast of the Black Sea, all beautifully situated, thus accomplishing its entire circuit, with the addition, moreover, of having traversed a very considerable portion of the Caucasian government, as well as Southern Russia, and, having crossed the Caspian, and visited the borders of Persia and Turkey in Asia.

We concluded a rough and uncomfortable passage, by finding the cholera raging in Constantinople, and were glad enough to re-embark as soon as practicable, and make the best of our way by Syra, Corfu, Trieste, Venice, Milan, and Paris, back to London.

It may be expected that, before closing this lecture, I should say a few words on the military relations between Turkey and Russia. It is frequently supposed that the great aim of Russia is to extend its dominions in Europe, and to annex Constantinople; but there are some reasons which make me doubt this. 1st. The enormous difficulties and dangers which, by insisting upon such a programme, have, and would again ensue to her; and, 2nd. That should Constantinople be annexed to Russia, it is by no means impossible that in consequence of the opposing interests which would arise between the north and the south, a dismemberment of the Russian Empire might follow. It would rather appear to me that the policy of Russia is to extend her dominions towards the east, not to Hindustan, for there the difficulties and dangers which would accrue to her by reason of a European war with a very powerful state like ourselves, are manifest. But by steadily adhering to a policy of never crossing to the south of the Hindoo-khoosh, she might gradually work upon the territories of the Chinese, and by also extending her dominions towards the south from the Amoor river she would annex to her already enormous dominions, highly fertile provinces, richly peopled by very industrious and clever races, who, not warlike, are mercantile, and would probably give her few difficulties in their subjugation. Thus Russia would be to a greater extent and more easily rewarded for her exertions than by any demonstrations that she might make against the nations of the west or the countries attached to them. Not only this, but should she establish a firm government on the Chinese seas, she would be able to cope with the development which the Anglo-Saxon races are making on the opposite side of the Pacific Ocean.

Evening Meeting.

Thursday, 26th June, 1873.

LIEUT.-GENERAL THE RIGHT HON. THE EARL OF ALBEMARLE, in the Chair.

NAMES of MEMBERS who joined the Institution between the 17th and 26th June, 1873.

LIFE.

Lindsay, W. J., Lieut. Rifle Brigade.
Richardson, J. B., Major R.A.
Houstoun, Geo. L., Lieut. Royal Renfrew Militia.

ANNUAL.

Crohan, Herbert, Com. R.N.
Brownlow, Sir C. H., K.C.B., Major-General.
Mitford, John, Lieut. Civil Service Rifle Volunteers.
Alt, J. W., Captain 15th Surrey Rifle Volunteers.

THE EDUCATION, AND PROFESSIONAL INSTRUCTION OF OFFICERS.

By Captain A. B. TULLOCH, 69th Regiment, Garrison Instructor, Halifax, N.S.

The CHAIRMAN: I have to call upon Captain Tulloch to read a paper on "The Education and Professional Instruction of Officers." I have only to regret that I am not some fifty years younger than I am, because then, I should have been able to derive some advantage from the paper, for I am afraid that I am now too old to learn. In my younger days, education was not so much thought of, and I may be somewhat in the situation of a certain "Claimant" of whom we have heard so much, and who did not know whether a regiment was in "close" or "open" order. I am very glad to see that those times are changed, and that meritorious young Officers are doing all in their power to make our profession one of the most practically well-instructed that can be found in the world. I believe that the strong, enthusiastic feeling, pervading all ranks of the Army at the present time, cannot be excelled in any nation of the globe.

Captain TULLOCH: In the military annals of our country, it would be hard to find any period in which greater changes have been made in the organization and administration of the Army than during the last two or three years. The causes, which have brought about the changes in question have been so often discussed, and are so well known, that I shall merely touch on that which has reference to the education and professional training of young Officers. I venture to bring to your notice my views on the subject, in the hope that, however crude, they may, nevertheless, do something towards throwing additional light on a question of so much importance.

Up to the year 1849, Officers were appointed to commissions in the

cavalry and infantry by nomination. When a young gentleman desired to enter the Army, all that was required for placing him on what was known as the Commander-in-Chief's list was that his name should be forwarded by some general Officer as a voucher for his respectability; once on the list, the name of the embryo ensign or cornet, in due time, arrived at the top, and if then of the proper age, he was duly gazetted, either with or without purchase. In certain special cases, gentlemen were gazetted soon after their names were placed on the list, but the usual practice was to take every one in his turn.

In time of peace, the demand for Officers was comparatively limited, and by far the greater proportion entered the Army by purchase; commissions without purchase were, however, given by the Commander-in-Chief to the sons of old and deserving Officers and others who had done good service to the state. A certain number were also annually granted to Sandhurst cadets, who passed special qualifying examinations, and a few were given to deserving non-commissioned Officers.

In February, 1849, a circular was issued, informing all candidates for commissions that they would have to pass an educational examination before being gazetted. The test was by no means a difficult one; any schoolboy who had received a respectable education could have accomplished it. The publication of the circular, however, appears to have created a regular stampede amongst the candidates, many of whom at once removed their names from the Commander-in-Chief's list. The examinations, instituted in 1849, continued in force till 1857, with this exception, that during the time of the Crimean war their stringency was so very much relaxed, that practically the examinations were a mere matter of form, and for a short time during the Indian mutiny, when the supply of soldiers did not equal the demand, free commissions were granted to any one who raised a certain number of recruits.

About this period, viz., in April, 1857, the Council of Military Education was established, and with it commenced a new era in the educational requirements and professional training of Officers. The examinations, instituted in 1849, being considered very unsatisfactory tests of a candidate's general education, the Council were directed to revise the whole system of examination for direct appointments to the Army. The head masters of the principal public schools in the country were therefore consulted with the view of ascertaining the amount of knowledge which might fairly be expected from young men of 17, and on the statements of the schoolmasters a new scheme was established in 1858. Now although the examination in question was by no means severe, the Council were nevertheless obliged from time to time to diminish the difficulty of it, owing to the inability of so many of the candidates to come up to the standard which had been practically established by those who had instructed them.

As an illustration of the value put on certain subjects of instruction by the head masters of public schools in 1857, it may not be out of place to mention that in the examinations then established, a candidate might obtain 2,000 marks in Latin, 1,600 in Greek, but in English or French, 1,200 only. By 1867, the obligatory portion of the examination

for direct commissions had been made very much easier; in English, $\frac{1}{6}$ of full marks was sufficient to qualify in that subject, and although a candidate might obtain 10,800 marks, a total of 1,500 was all that was necessary for passing. Notwithstanding the apparent mildness of this test, hardly any boys, educated at the public schools, dared venture to attempt it without previous preparation by a crammer.

Now with reference to professional training. An Officer on joining his regiment was, as a matter of course, taught his drill, but any knowledge of his profession beyond that which could be obtained in the barrack square, he had little or no means of acquiring. The subalterns were generally assembled once a week in the ante-room for school, under one of the majors, but in nine cases out of ten the subject of instruction, if instruction it could be called, was confined to the bare routine of battalion drill. In this weekly school, even when instructing in ordinary drill, there always appeared to be a great want of system, a defect which was also very conspicuous in what were known as adjutant's parades. In some regiments, Commanding Officers used to detail the movements—usually restricted to three—which were to be performed under the adjutant, but in many cases he was allowed to execute any manœuvres he chose, the result being that from continually knocking about the battalion as he pleased, the most stupid adjutant in time got the reputation of being a good drill, but he alone of all those present on parade really profited by the performance. Another very impolitic measure by which drill was made distasteful to young Officers was the prevailing custom of requiring all Officers junior to the adjutant to attend his drills, thus the presence of an Officer at a parade, which was often looked on as a mere waste of time, depended not on his efficiency, but on the adjutant's place on the list of subalterns.

Before finally leaving the question of adjutants, it may not be out of place to notice what has occasionally been suggested, viz., that they should not be allowed to hold office as such in regiments for more than two or three years, so as to give as many of the best Officers as possible a knowledge of adjutant's work, such work being about the very best that could be devised for making a first-rate Officer.

But to return to the subject more immediately under discussion. In addition to school in the ante-room once a week, subalterns were by an order dated 19th January, 1859, required to send in a report and sketch of the country whenever the battalion was exercised in route marching. Those Officers who had been educated at Sandhurst usually made out readable sketches and reports, some being remarkably good, but the productions of those who had never received any instruction in delineating ground or in making a concise military report were, as might be expected, simply so much waste paper. Orders were complied with, certainly, but practically the whole affair, as far as the training of the uninstructed Officers was concerned, was useless.

Occasionally Commanding Officers, who knew from experience on active service how important it was that every Officer should be instructed in outpost work, did their best to give both Officers and men some training in that duty; the opportunities for doing so, how-

ever, especially in this country, occurred but seldom, Commanding Officers being strictly prohibited from trespassing on private property.

As regards examinations for promotion, they were first instituted in 1850. Ensigns, before being recommended as fit for advancement in rank, were required to show that they were acquainted with their drill, regimental duties, Mutiny Act, and Articles of War. Lieutenants before promotion were informed that, in addition to the examination in drill, &c., they would also be required to pass an educational test, which must have made the gray hairs of many an ancient subaltern stand on end with astonishment, the subjects in which Officers in question were to be examined being as follows:—History, ancient and modern; first six books of Euclid; properties of the circle; algebra, to quadratic equations, inclusive; logarithms; plane trigonometry and mensuration; permanent and field fortification; military law, &c. As a matter of course such a terrible ordeal was rarely, if ever, enforced.

In 1858, the regulations with reference to promotion were revised, the examinations being made entirely professional, and confined to those subjects which a regimental Officer ought to know. With some slight revisions, these tests as ordered in 1858 continued in force until 1870, the only real difficulty in the examinations being that which related to field fortification, reconnaissance and outpost work. Having little or no opportunity of receiving instruction in such matters, Officers were obliged to get them up as best they could from books, those books, in which the different subjects were compressed as much as possible, and with the contents arranged in the form of question and answer, being the favourites. The great drawback, however, to such a method of getting up a subject, about which the candidate really knew nothing, was that occasionally question and answer did not fit. At one examination which I happen to remember, an Officer described a gabion as a fortification made of sand bags, &c., whilst another said it was a redan with flanks.

In 1870, commenced the first of a series of the most important changes with regard to the first appointment and training of Officers which had taken place for many years. The Military College at Sandhurst, after having educated cadets for nearly three-quarters of a century, ceased to do so any longer, and in the year following the old method of appointing Officers by nomination and purchase was abolished, the time-honoured rank of Ensign or Cornet being replaced by a new designation—Sub-Lieutenant—the status of which, by the way, does not appear to be clearly defined,—and the Army was in future to be supplied with Officers by assigning a proportion of the vacant appointments for public competition, and by giving each Militia regiment of a certain strength the nomination of one Lieutenant's commission annually, the remaining vacancies being filled by candidates from the universities, Queen's Cadets, and deserving non-commissioned Officers.

The new grade of Sub-Lieutenant differed from that of Ensign in that the appointment was only probationary. Sub-Lieutenants were

to serve about a year with their regiments, where they were to learn their drill, interior economy of battalion work, and such like; if then favourably reported on, they were to be sent to the Military Collge at Sandhurst for instruction in surveying, fortification, &c. The Sandhurst examination successfully passed, the Sub-Lieutenant was then gazetted as a *bonâ fide* commissioned Officer, with certain antedates.

Considerable changes were at the same time also made in the examinations for promotion after entering the service. A knowledge of field fortification, military surveying, elementary tactics, and military law being now required (in addition to the former subjects), a special examination in the branches just named was then instituted; and in order to give Officers opportunities for acquiring such professional knowledge, Garrison Instructors were appointed at all the principal stations at home and abroad. Being the first Officer nominated to fill one of these appointments, it is to the working of the new system and the deductions derived from nearly three years' practical experience of an Instructor's work that I now more particularly desire to direct your attention.

The Garrison Instructor being an entirely new species, was at first looked on with rather a suspicious eye by the younger Officers, who seemed to think that they might suddenly be seized by him as by a bird of prey, and carried off for immediate instruction; the first result of my arrival amongst them was a general rush to pass the examination for promotion under the old rules, in order that they might thereby save themselves from falling into my clutches.

The professional, not to say prophetic, knowledge attributed to the Instructor was at times quite startling. One Officer of some standing gravely asked me just before the outbreak of the French war to give a lecture on the subject, and inform them what was going to happen.

The departments also were occasionally rather at sea about the new appointment, and I am afraid that I must have given them a good deal of trouble with my strange requisitions; nevertheless they were none the less willing to do everything in their power to help me.

The young Officers finding at last that the Garrison Instructor was a very mild, inoffensive individual, and by no means likely to suddenly explode in their midst, and annihilate them with fragments of learning, became less suspicious, and eventually I commenced my first course with a class composed of four Officers, who must have made a favourable report of what had happened to them, for afterwards I rarely had less than a quarter of the Captains and subalterns in the garrison under instruction at a time, and with two exceptions only, more willing pupils it was impossible to wish for. The only decided obstacle I had to contend with was the very imperfect education which many of the Officers had received when boys at school. You will be rather startled to hear that I never yet had a class in which I was not obliged to teach some of the Officers composing it vulgar and decimal fractions, and I specially remember that a very simple rule of three sum was on one occasion too difficult a problem for any one in the room. Equations were things which many had apparently never heard of, and the Officer who could write a concise report, especially in a legible

hand, was, in some classes, rather a *rara avis*. As regards subjects of general information, I also found in two or three instances an astonishing deficiency of education. There passed through my hands representative pupils of many English schools, and from the information obtained from different Officers, I came to the conclusion that several of them had had their time almost entirely wasted at school, and that their only acquirement had been a smattering of Greek and Latin.

A classical education, when *completed*, will have disciplined the mind possibly quite as much as a mathematical one; but when a so-called classical education stops before it even gets to the threshold of completion, I cannot but think that so much time taken up in stringing together Latin verses and in wearily plodding through Virgil or Homer, almost to the exclusion of other subjects, is time misued.

I by no means wish it to be understood that all the Officers who attended the classes were badly educated, very far from it, some having taken their B.A. degree at college, but this I do mean to say, that fully one-fourth of them had received a very defective education indeed. How the schoolmasters that professed to have taught them could have been satisfied with their work I cannot understand. With two or three exceptions, there was no want of natural ability shown by those Officers who had been so badly educated; but unfortunately it took a very considerable portion of the four months during which the course lasted to get some of them into the habit of using their brains at all. At times, their intellects seemed suddenly to awaken as if startled from sleep; occasionally the process was more gradual, but as soon as this change had taken place and they began to think for themselves the great difficulty of instruction was overcome, and some of those who appeared very dense at the beginning of the course turned out remarkably well afterwards. Some few,—fortunately I had never more than two in any class,—were naturally so defective in intellectual power, or had received so little attention when at school,—I am strongly inclined to believe that the latter was the true state of the case,—that the labour of imparting instruction to them became almost a physical one. I have often, after only three hours' with the class, been quite as much exhausted as if I had been pulling a heavy oar all the time. Had it not been for the willingness, in fact I may say the intense desire on the part of the Officers referred to, to obtain professional information, it would hardly have been possible to have continued the uphill work of instructing them.

As regards the question of Officers being desirous of instruction, many people fancied that they would not care to return to what might appear rather like schoolboy work; that fear is now a thing of the past. Very young Officers who have just escaped from the thraldom of school do not, as a rule, take to book work so well as those who have been longer in the service; but I can safely say that it is the exception for an Officer of any standing not to be desirous of improving his professional knowledge by going through a course of garrison instruction. Of course there are men to be found in the Army, as in every other profession, who are so deficient in mental stamina that exertion of any kind, even for the most fascinating of field sports, is

distasteful to them. Fortunately such hard bargains are not numerous, and in some regiments do not exist; they of course are not to be found amongst the Garrison Instructor's voluntary attendants.

With reference to the support given to the system by Commanding Officers, all I say is that it would have been impossible to have wished for more. From the General commanding, downwards, everyone took the greatest interest in its success. As soon as the nature of the course was understood the Colonels of the different regiments offered to change parade and orderly-room hours, or do anything that I could suggest for the purpose of enabling as many Officers as possible to attend, they themselves being present when any out-door work was going on. With regard, however, to the facilities for continuous study without interruption from regimental work, I think there is room for improvement. A very excellent feeling prevails in most regiments, and especially in those where *esprit de corps* runs high, which makes Officers averse to being struck off duty and thereby throwing their work on others. Several Officers, in fact all the Captains, except one, who went through a course of instruction, declined to be struck off duty, they merely got leave from parade during the time the course lasted, and did their company work and the duty of orderly Officer of the week when I did not require them.

Captains and Subalterns had occasionally hard work to be in time for lecture after being present at orderly-room with their prisoners, &c. A conveyance of some kind was usually kept waiting just outside the orderly-room, and as soon as their work was done they came down at full speed to the class-room.

Sometimes much valuable time was lost from interruptions such as I have mentioned, which made me almost decide that unless Officers would consent to being struck off all duty, so that their attendance with the class might not be interfered with, I would not undertake to put them through a course of instruction; but on considering that the Commanding Officers had done everything that was in their power to enable as many Officers as possible to attend, I came to the conclusion that it was my duty, and the better policy, to leave matters as they were and do the best I could under existing circumstances. The willingness on the part of the Officers to attend, in spite of all obstacles, was indeed in itself a sufficient reason for overlooking such irregularities. Many a time have I admired their determination not to be a minute late for lecture, although the weather in winter was at times hardly faceable, with the thermometor 10° below zero and a breeze blowing that sent the *poudré* snow into the innermost recesses of one's wraps. Schoolmasters at home would be rather astonished at finding their pupils obliged to make their way to school on snow-shoes. At Halifax it was no uncommon thing for Officers to get frost-bitten on their way from barracks to the class-room.

At the request of a Commanding Officer, who justly considered that instructed non-commissioned Officers would be invaluable assistants to an Officer who had to put an outpost or position into a state of defence, I obtained authority for establishing a class for sergeants, none but the most intelligent being sent. The result was very satis-

factory. I was quite astonished at the aptitude many of them had for using a pencil. To enable them to attend regularly they were excused guards and parades, but nothing else; they had even to arrange for some one to do their orderly work. To give you an idea how they took to instruction, I may say that, amongst others, a sergeant-major of one of the smartest regiments in the service went through a complete course, and the only part of his regimental work from which he was excused was attendance at Commanding Officers' parade, and orderly-room afterwards, when possible. I am happy to say that he passed an excellent examination; his road, river, and out-post reports were certainly amongst the best I had ever read; they were clear, concise, and written in a very legible hand, which last is really no small recommendation.

The result of observations made on the working of the system of garrison instruction may, I think be summed up as follows:—

1. That a considerable percentage of Officers have had the elementary portion of their education so neglected that they are unable to benefit by instruction as much as they might otherwise do.

2. That Officers are, as a rule, very desirous of acquiring professional knowledge, such as is given in a course of garrison instruction, and that they will put themselves to any inconvenience imaginable to attend a course.

3. That owing to regimental duties of various kinds, social as well as professional, an Officer undergoing instruction, when with his regiment, is liable to a detrimental amount of interruption of work during the course.

4. That instruction in any but temperate climates is carried on under considerable disadvantages.

5. That many non-commissioned Officers are anxious for professional instruction, and that a considerable portion of those are well qualified to receive it.

To meet the different requirements indicated by the conclusions just mentioned, it would be necessary first of all to demand that the elementary education of candidates for commissions should be more attended to.

As regards Officers, it certainly seems that when undergoing instruction they would be better away from their regiments, and might receive instruction to greater advantage if sent to institutions analogous to those at Shoeburyness and Hythe.

With reference to non-commissioned Officers, a more elementary course might be arranged for them, the instruction being given by a duly qualified subaltern of the regiment to which they belonged.

Before going into the details connected with these proposed changes, it will be necessary to refer to the present method of supplying the Army with Officers. It has already been stated that vacant appointments are to be filled by Militia subalterns, candidates from the universities, Queen's Cadets, or by open competition, the three last-named classes receiving probationary appointments confirmable on their passing certain professional examinations, after about eight months' instruction at Sandhurst. Concerning the Militia candidates

and Queen's Cadets, who only require to pass a qualifying examination, I will now say but little, except that, in fixing the standard of the examination, care should be taken that no one be allowed to enter the service unless most thoroughly acquainted with elementary arithmetic, and also able to write an ordinary letter or report in clear concise language and in a legible hand. It is certainly impossible to appreciate too highly that peculiar training at public schools which develops those qualities so requisite in an Officer, viz., gentlemanly feeling and manner, and a love of amusements requiring physical strength and skill, but as regards book learning, I cannot help thinking that too much time is still sacrificed to Greek and Latin to the detriment of more useful accomplishments. Not one Officer in a hundred, perhaps not one in five times that number, ever opens a Greek or Latin book after entering the service. If in pursuit of some particular study, one requires to refer, for instance, to Pliny or Herodotus, an English translation at once supplies the information wanted, probably in much better form than any ordinary classical scholar could render it. Many an Officer who desires to improve his professional knowledge finds himself stopped almost at the very commencement of his efforts from inability to read French or German; frequently have I heard such men rail at the time wasted at school in learning the dead languages, of which they then hardly recollected a word.

Before quitting the subject of Militia candidates, I may suggest now that that force and the Line are to be united, the more closely they can be drawn together the better. It is to the Militia that I think we must look in time of war for the reserve supply of young Officers, without which, reserves of men are of comparatively little value. Militia subalterns might be encouraged to go through a Sub-Lieutenant's course on the understanding that all vacancies which occurred in the Line battalions of their brigade, when on active service, should be filled by Lieutenants who had so qualified, provided that at the time of appointment they were not too old—say not more than 24 years of age. With such inducement, it might even be possible to obtain supernumerary subalterns for the Militia. I may here observe that those Army reformers who so persistently state that the Army is overofficered can have but little idea how rapidly regimental Officers are used up. As soon as the organization of a force for field service commences, staff, train, field depôts, and in fact every department without exception in one way or other demands Officers from the Line, the result being that a regiment which actually takes the field with two Officers per company is rather lucky than otherwise. On one occasion, when performing the duties of adjutant, the inadequate number of Officers in my regiment was particularly brought home to me. At the time in question we were engaged in what proved to be rather a short campaign; but one Officer had died, and only two had been sent away sick; nevertheless the departments had absorbed so many Officers, that on the regiment parading, for what might have been a heavy day's work, there remained but one Officer per company, and two for the colours. I remember being rather puzzled as to whether, in the event of any casualties happening amongst the Captains or subalterns, I

should be afterwards justified in allowing the colours to be carried by sergeants, in order that every Company might, if possible, be commanded by an Officer.

But to return to our more immediate subject—the present entrance examinations. With reference to the system of open competition, which is such a favourite with some people in this country, all I can venture to say is that many persons, who are no mean judges of the question, are much opposed to it, and that in the Army especially, where certain requirements of character are of far greater value than much learning, competition is out of place. The old method of nomination certainly possessed one very decided advantage over the present regulations, inasmuch as that no person could get his name placed on the Commander-in-Chief's list without a guarantee, from some Officer of high standing, that he was a fit and proper person to hold Her Majesty's commission. In time of war, when there was a great demand for Officers and no reserve to fall back on, it was not always possible to adhere to this rule; the pernicious effects consequent on its infringement are well known to every Officer who was in the service seventeen or eighteen years ago, and ought to be a warning that something more is necessary than a mere certificate of moral character from a parish minister or schoolmaster. But putting that question aside, the competitive examination is subject to a drawback which is common to all such methods of testing the qualifications of candidates, the defect being that such examinations encourage, in fact almost oblige, those who wish to give themselves every chance of success to have recourse to teachers who make it a special business to prepare candidates. Cramming, as the process is popularly termed, does undoubtedly pay, no matter what examiners may do to discourage it.

The fees demanded by crammers are very heavy (but certainly not more than they deserve for their work), and it is not every one who can afford to pay them; consequently those candidates who are not well off, the sons of old Officers, for instance, will be very heavily handicapped in this new competition struggle.

With a view to induce some one, better qualified than I am, to arrange some scheme for placing the sons of Officers on an equality with their richer neighbours, I think I cannot do better than direct attention to the circumstance that the Military College at Sandhurst was originally established in a great measure for the education of the sons of Officers partially at the expense of the public. At the abolition of the Cadet College in 1870, the amount annually granted by Parliament was about £20,000. Officers have now ceased to derive any benefit from an establishment which was a great boon to the Army for many years. The establishment of a school for the education of the sons of Officers, is too much to hope for, and might not be advisable: perhaps, however, as the Sandhurst grant, by which Officers benefited considerably, has come to an end, an annual sum might be voted for Army scholarships in the different public schools of the country which give, what is called, a modern education.

While on this topic, one educational institution should not be forgotten, viz., Wellington College, which was established as a memorial

of the great Duke, and for the education of the orphan sons of Officers. About £159,000 was subscribed by the Army and the public, and £25,000 was added from the Patriotic Fund, in return for which about 80 boys are maintained and educated on the foundation, at little or no expense to their friends. Eighty foundationers certainly seem rather a small return for £184,000, but the matter is, perhaps, to a certain extent, made up to the Army, in that the sons of Officers are educated at the College for £30 a year less than the sons of civilians, who are permitted to participate in the benefits of the Institution. The advantageous position occupied by the sons of Officers is, however, somewhat theoretical, as their education, even at the reduced rate, costs £110 per annum. Why education at Wellington College should be so much dearer than at the popular and most successful proprietary college at Cheltenham, it is difficult to understand.

Now that Wellington College—which in a certain sense belongs to the Army—is regularly established as one of the educational institutions of the country, might it not be enlarged at a comparatively slight expense, as regards original cost for building, so as to take in a much greater number of boys, sons of Officers in the Army and Navy? The construction of eight or ten additional class-rooms and boarding-houses and the salaries of a similar number of tutors and assistant-masters would not be much to ask for, in part compensation for the abolished Sandhurst grant. With instruction provided at the public cost, £55 a year, or rather for nine months (three months being absorbed by the holidays), should be ample for a boy's board and all other expenses (clothing and pocket-money excepted), provided the boarding-houses were properly supervised, and all unnecessary expense and extravagant habits prohibited.

Having pointed out what appears to be the weak points of the new system of entrance examination, I will now pass on to technical instruction, considered necessary after joining the Army. With reference to the professional education of Officers, I think that one of the principal disadvantages attending the present system of garrison instruction, viz., interruption of work, might be got rid of by amalgamating the establishment at Sandhurst and the classes of the garrison instructors in this country, forming therefrom two or three large schools for professional instruction—two for England and Scotland and one for Ireland. The College at Sandhurst already exists, the establishment of the remaining two need not be very expensive. A few class-rooms, a lecture-hall large enough to accommodate 100 people, a modelling-shed, and four or five acres of practice-ground, would be alone necessary. Of course, quarters would be required for the Officers and Sub-Lieutenants attending the school. The country in the vicinity should be open and undulating; if a river happened to be near, so much the better.

By combining the instruction of older Officers with that of Sub-Lieutenants, a steadying element would be introduced, a want which appears to have been lately felt at Sandhurst. In suggesting these schools, where I consider a course might be thoroughly completed in four months, I start with the assumption that only those professional subjects which are indispensable to a regimental Officer, and which he

cannot acquire elsewhere, should be taught, viz., field fortification, military surveying, elementary tactics, and military law.

Everything else which a subaltern must be acquainted with, such as drill and interior economy, should be imparted to the Sub-Lieutenant when with the home regiment of the brigade, instruction in those matters being under the superintendence of the Major of the battalion.

I also assume that every Officer is capable of undergoing 30 hours of study or out-door work in a week—six hours a day and a holiday on Saturday. Cadets at Sandhurst had 33 hours' work per week. In seventeen weeks there will, consequently, be 510 hours in which to go through the entire course. The time to be divided as follows:—

Fortification lectures, one hour each	25 hours
Elementary tactics, including outpost and advance guard work, &c., lectures one hour each.....	20 ,,
Outlines of strategy, just sufficient to show the meaning and necessity of a base of operations, line of communication, and such like, lectures of one hour each.....	5 ,,
Military drawing, 20 lessons of two hours each.....	40 ,,
Fortification drawing, 15 lessons of two hours each	30 ,,
Military law, lectures of one hour each	12 ,,
Total.....	132 ,,

Thereby leaving, for the practical outdoor work connected with sketching and fortification, 378 hours. That 510 hours are fully sufficient for the course proposed, will, I think, be allowed, when I state that a course of garrison instruction has to be completed in 255 hours.

By concentrating the instruction in two or three large schools, there would be this special advantage with regard to the instructors, viz., that each might confine himself to that one subject for which he had a speciality. The supply of large models, material, and labour might, practically, be unlimited, all of which would greatly facilitate the work of the instructors.

Now to get over the difficulty about senior Officers objecting to being struck off duty. At present four subalterns per regiment are not unfrequently off the regimental roster, for the purpose of attending the course, with as little interruption as possible. Instead of four subalterns per battalion, limit the total number of Officers allowed to attend to four, including Captains; and subsequently, as soon as promoted, and consequently instructed, Sub-Lieutenants begin to join the battalion, reduce the number of Officers allowed to leave the regiments for the purpose of attending the schools to three, and afterwards to two. A regiment could stand having two duty Officers away at a time undergoing instruction, more especially if Officers on the staff were seconded, as they certainly ought to be. Sub-Lieutenants being merely with the battalion to learn their drill and regimental work, could not as a matter of course be included in the list of duty Officers.

As regards regimental instruction for non-commissioned Officers, it has been suggested that the Musketry Instructor might undertake it,

but that would not be possible, for this reason, that during the summer, when the out-door practical part of the work would be going on, the Musketry Instructor has his time very fully occupied with the annual course of rifle training. If any attempt be made to put non-commissioned Officers through an elementary course, and to teach the men how to handle a spade or pick when close together, on a working party, to make gabions, and so on, a regular instructor should be appointed for the purpose; he might be selected from those subalterns in the regiment who had been through a school of instruction. If the instructor's work did not exceed three hours a day, he might, in addition, be required to superintend the management of the canteen, recreation room, regimental workshops, &c. The present canteen system is one of the greatest benefits conferred on the *private* soldier for some time past, but many Officers dislike exceedingly being obliged, whether they will or no, to attend to work which is anything but professional; neither do they like having thrust upon them the responsibility and anxiety consequent upon keeping a large grocery store and beer-house, in doing which they may unavoidably lose, and many have lost, considerable sums of money. Were the duty in question part of a paid regimental instructor's work, one great drawback to the canteen system would be got over.

Before taking leave of the question of instruction, it may be as well to suggest how Officers are to keep up what they may learn at the schools, and also how they are further to improve their professional knowledge. I think a suitable plan for so doing may be arranged by taking a hint from both the Prussians and the Americans.

Instead of confining ourselves to marching out reports, and sketches, why, when so many Officers are qualified to do so, should we not adopt the Prussian plan to a certain extent, and let the Officers of each company in turn practise, say twice a year, those duties which they would be called upon to perform on service, such as strengthening an outpost, arranging a plan of attack or defence adapted to a particular piece of ground, and so on? Officers would take the greatest possible interest in such work, and the Colonels of regiments would have a better opportunity of ascertaining the capabilities of their young Officers than they have at present. The plans and reports to be laid before the General at inspection, with the companies' books, each Officer being called up in turn to answer any question, concerning his plans, which the General may ask.

Now with regard to the American idea. In that country, where people are so desirous of information on every possible subject, public lecturers travel from city to city. Might we not institute something of the same kind for the benefit of those Officers who wish for advanced instruction in strategy and tactics, such as is given at the Staff College. Officers who are recognized authorities on such subjects, and who are at the same time really good lecturers, are few in number, but as three lecturers would probably be sufficient for the purpose suggested, that number ought to be obtainable if the appointments were well paid. The lecturers might take the large garrisons in their districts in rotation, giving a course of, say five or six lectures on each visit.

In conclusion, I venture to hope that I may never again hear that senseless cry, raised by men who know nothing of the service, that young Officers are a careless, happy-go-lucky lot, who think only of amusement. In no profession will you find men so anxious for professional information, in none will you find men so willing to go through difficulties to obtain it; but give them the opportunity of learning their work, and they will show themselves to be as superior to continental Officers in the more elaborate training required for warfare in the present time, as they were in those glorious days of old, when the simple English line proved superior to all other formations for attack or defence. Some young Officers, by reason of the defective education which they received when at school, are unable to benefit by instruction as much as they might otherwise do. If my lecture has any effect in directing attention to the subject in question, it will not have been given in vain.

The CHAIRMAN: The subjects for discussion are as follow:—

1. Ought any alteration to be made in the present qualifying Examination for Commissions, for the purpose of inducing the masters of schools to pay more attention to instruction in Arithmetic and English Composition?

2. Would it be advisable to establish two or three schools, analogous to Hythe or Shoeburyness, for the instruction of Officers, in place of the present system of Garrison Instruction?

3. Ought Non-commissioned Officers to go through a short practical course of Field Fortification, to enable them to act as assistants to their Officers? Would it be advisable to have a Regimental Subaltern Instructor to teach the Non-commissioned Officers; the Instructor in question to superintend the canteen, regimental workshops, &c.?

4. Would it be possible to obtain the services of two or three good lecturers on Strategy and Tactics who would give regular series of lectures (similar to those given at the Staff College) at certain large military stations in the United Kingdom?

5. The Sandhurst grant, by means of which Officers' sons were cheaply educated, having come to an end, might it not be renewed in the form of Army Scholarships?

6. Would it be feasible to enlarge Wellington College for the benefit of the Army and Navy?

7. Would it be possible to form a Reserve of Subalterns for the Line, who should serve with the Militia in time of peace?

Sir THOMAS DYKE ACLAND, Bart., M.P.: If the first question be passed over as admitting of no controversy, I, though only a civilian, may take the liberty of saying two or three words. I think we are very greatly indebted to the gallant lecturer for the strong stand he has made in favour of education, both unprofessional and professional; and still more must those of us who are connected with Officers in the Army, feel grateful to him for that testimony which he has borne, and which many civilians might also in their humble way bear, to the zeal for knowledge which, I believe, for a long time past, has pervaded the Army. The difficulty in which young Officers were placed in former years was, first of all, that their time was so wasted upon routine duties, if I may presume to say "wasted," that a man never knew what time he had for study; he was always liable to be called out on the most ordinary matters of routine, and placed in a position most unfavourable to study. And, in the next place, I am rather mistaken if a young man sometimes was not liable to be called to account for intending to be a General before he was a Captain; and so young men were sometimes driven into a corner, and almost pretended to think study was useless when in their hearts they really would have been very glad to have been encouraged to study. With regard to the first point, I must, apparently at least, differ a little from the lecturer. It may be my public school prejudices, but I am rather mistaken if the opinion of Commanding Officers generally would not be very favourable to the qualities of an Officer in the

Army who, perhaps, having no experience of military command, might be sent on board ship with a draught or body of men under his command, if he had happened to be captain of the boats at Eton. I have heard the remark made, that young fellows fresh apparently from London society, and an assumed life of great idleness, have shown extraordinary qualities of command, which could only be accounted for by their public school training. I must differ from the lecturer when he seems to say that a man learns at a public school only gentlemanly manners and fondness for amusement. I am quite alive to the idleness of public schools. I have perhaps had some share in it myself, and I have seen a good deal of it in some of my young friends who I should like to see a little more diligent. But I think that boys do learn a great deal at public schools unconsciously; and if you are to lay down the principal that a young Officer does not want Greek and Latin afterwards, because he can read from a crib if he wants to know what Herodotus or Polybius may have said on military matters, no doubt he may do so; but that is not education, boys do not learn Greek and Latin at school, in order to be able to hunt up some passage from a Greek or Latin classic. They learn Greek and Latin in order that they may get not only a gentleman's education or a merchant's education, but that they may learn what human beings are and how to command their fellow-creatures, and how to obey those who are set over them. Classical literature, if of any use at all, is so, because it is human and because it calls out that in man which is of most importance for him to know, especially if he is placed in command over other people. Captain Tulloch has suggested that more attention be given to English composition. I never was taught English Grammar when at school, and I have had to work very hard at English composition in a particular line of occupation which fell to me as a matter of duty, for I had to learn English after I was forty years old. I very much doubt, however, whether learning English Grammar at school would have taught me half as much as learning Latin Grammar did. I doubt also whether if you are to say that boys, because they are to go to the Army, should not learn Greek and Latin, but should learn French and German, you would mend the matter very much. However, I am perhaps getting too much into the question of what is a sound English education. Let us turn to experience—what is the great strength of the Prussian Army? First of all, the Officer of the Prussian Army is essentially a born gentleman; secondly, he is not only a born gentleman, but he is a generally educated gentleman. He must go through an unprofessional, classical, and mathematical education, if I am not greatly mistaken. I am not sure how far certain military schools are really general. I may be mistaken about the Officer, but I am pretty certain I am not mistaken about a large number of the Non-commissioned Officers. The "Einjährige"—one-year man—is essentially an educated man. He goes into the ranks to serve for one year, and he gets that privilege, not merely because he has money enough in his pocket to pay for his outfit, but because he has been at a gymnasium or a Realschule, and has had a good general education, and he must absolutely have proved, by examination, that he has had a thorough and general education. These men, if I am not mistaken, are the life and soul of the Prussian Army—a link between the private and the educated gentleman, who is the Officer. They become Non-commissioned Officers in the Army, and afterwards Officers of the Landwehr. If that is a fact, it is a strong testimony in favour of a general education. I hope I have not spoken too eagerly; but I beg to hail, with thanks also, another sentiment from the lecturer, which is, that some kind of inducement in the nature of scholarships should be held out to our schools generally. I have had a great deal to do with the middle schools of England; and, I am sure, nothing has done more good in England than giving an open career to all our public schools, grammar schools, middle schools, private and public, and bringing them all to the test of university examinations. I believe that the more you have free trade in education in England—if you only keep up attention to the social position and gentlemanly feeling which pervades educated men generally, even although they may not have been very highly born to begin with—the more freedom you give, the better preparation will you give to a man, either for a position of an Officer in the Army, or any other position in which he may eventually be placed.

Major KNOLLYS: As Garrison Instructor, my Lord, I have naturally had my

attention very much turned to the subject on which we have heard so able a lecture to-night. It is impossible to overrate the importance of the present step in the direction of increased attention to Military knowledge. Previously to the Crimean war, the state of Military education was at its lowest ebb. It is easy to account for that fact. Until General M'Dougall, about 1855 or 1856, brought out his work upon the Art of War, there was scarcely a book in the English language that treated of that subject. There were one or two, but they were very little known; and these did not deal with the subjects of strategy and tactics as a whole. Another very great reason for it was an entire misapprehension of the practice and ideas of some of the most celebrated warriors of modern times. The Duke of Wellington has often been quoted as a man thoroughly practical, who achieved his great successes by dint of hard common sense, aided by a natural talent for war, and considerable experience. It may not be generally known that the Duke of Wellington never passed a day without devoting some portion of it to reading. Then take Napoleon. There never was a man in this world who had a greater natural talent and genius for war than he had, and yet no man studied more assiduously whenever he had leisure than did Napoleon. From an ignorance of these facts, and from the long time that we had been at peace, Military education had sunk, I say, to a very low ebb, and was almost despised. Military discussion on professional subjects was eschewed. Anybody who attempted it would have been put down as a prig at once, and it would have been said he was guilty of "talking shop." I remember myself, 20 years ago, coming from country quarters to a lecture at this Institution, and I recollect being called "a "young fool" for my pains. It made a very great impression upon me as marking the state of feeling in those days. Now, the importance of study is fully recognised, and the only difficulty is to indicate the best means of acquiring the best sort of study in the best possible manner. Still, even with this great appetite for knowledge, which we see all round us, and which I thoroughly believe to exist, the remains of the customs of the dark ages are barely now passing out of sight. I remember, a year or two ago, a certain Officer who, for a short time, attended some of my lectures, though he did not *attend* to many, for he was generally asleep, underwent an examination under the old rules, and being asked what a "gabion" was, said he thought it was "a sort of field work." He was asked to describe field fortification, and he said his idea was that it was "a field surrounded by forts."

With regard to the first point in the programme for discussion, I must say I have felt, as Captain Tulloch says, under very great difficulties in conducting instruction in my class, owing to the want, on the part of a large number of those who have been at the public schools, notably at Eton and Harrow, of even an elementary knowledge of geometry. In some cases I had to explain what an "angle" was, a "radius," and a "circumference." There was an amount of ignorance manifested that I hardly could have believed, had I not actually come across it in practice. That, of course, took up a great deal of my time to remedy. I had to do the work of a national schoolmaster, instead of fulfilling the higher functions—as I venture to believe them—of a Garrison Instructor. Besides that, I found that from want of study and mathematical instruction, their mental faculties were not trained to the acquisition of knowledge. These men were slower in acquiring new facts than those men who had received that admirable training which mathematics gives more than anything else in the world. With regard to classics, I have not had the advantage of being at Eton or Harrow, neither have I had the benefit of a regular classical education; but though I thoroughly recognize the advantage of the latter, I must say that it should be looked upon as an accomplishment rather than as a necessity. It is extremely desirable if you have time for it; but we should put everything in its proper place according to its relative importance. In these days of struggle for life and advancement, French and German are more important. After you have learned these things, then, by all means, go to your classics—polish your style. As to the immense use it is with regard to writing the English language, I would say, in reply to the gentleman who has just spoken, that I never was taught English Grammar in my life, and if I had not learned the Latin Grammar, I do not know where I should have been. I must say, however, that was certainly rather an indirect way of learning to speak my own language, and I am very sorry that I was not taught English Grammar. I may also mention with regard to obtaining historical information from the classics by

means of a crib, that Napoleon did so habitually. He carried a carriage-full of cribs about with him in all his journeys.

With reference to the second point, as to whether it would be advisable to establish two or three schools analogous to Hythe or Shoeburyness for the instruction of Officers, in place of the present system of garrison instruction, I do not quite see the necessity for it. Sandhurst is taking all the minor elementary work of the Garrison Instructors, and the functions of the Garrison Instructor should be confined chiefly to giving incidental lectures—to taking the senior Officers and lecturing them on strategy and tactics. Moreover, I myself am very strongly impressed with the importance of imparting education to young Officers regimentally, instead of either at Sandhurst or in courses of garrison instruction. I think you cannot overrate the importance of carrying on the instruction in drill, and what you may call the social military education of the young Officer at the same time with his technical education, and further, when an Officer is being instructed in his regiment, he knows that it is essential for him, if he wishes to be successful in life, to gain the good opinion of those about him, whereas, at Sandhurst, within certain limits, the good or bad opinion of the superior Officers has very little effect on his standing and position in the estimation of his own regiment. There is another objection to Sandhurst, viz., that there you have a number of young fellows brought together. The tendency of young men is to fall into thoughtlessness and irregularities, and they naturally encourage each other; whereas, in a regiment, the one or two young fellows would be completely leavened by the older hands, who would keep them in the proper groove. The strongest of all objections to Sandhurst is this: that after a young fellow leaves school and spends a year in comparative freedom and independence in regimental life, it is not reasonable to expect him to submit again to the necessary restraint attendant on such a course of academical instruction as is proposed. It is as reasonable to expect a tiger-cub, after tasting blood, to return to bread and milk.

With regard to the third question, I think it is extremely important that there should be a regularly trained non-commissioned Officer in each regiment to take charge of the working parties or to assist the Officer in charge of these working parties. I cannot see any possible difficulties in the way of this; it would be only necessary to send him to Chatham, or some other place, where there is a company of Engineers, and the expense would be only the cost of the railway journey. I agree with Captain Tulloch in what he said about the non-commissioned Officers, for, of all those that I have had to teach, I think the most eager in listening to lectures, and the most anxious to gather instruction, have been non-commissioned Officers and Officers of the auxiliary forces. They are men of a certain age—at least they have got over all the freshness and rawness of youth; whereas the men that I have had to deal with in my regular classes are young, and, though they are intelligent and very fine fellows, and men who, years hence, will thoroughly appreciate the advantage of learning, you could hardly expect them to be very keen to return to their books after such an extremely short holiday as they have had. As to the capacity of non-commissioned Officers for profiting by instruction, I must say it is of a very considerable amount. I have seen and read some most admirable sketches and reports prepared by non-commissioned Officers. With regard to the subaltern instructor, I am in favour of having instruction given altogether regimentally by one Officer appointed as the instructor of a regiment, and I think that one Officer would be able to undertake the instruction of the Officers of his regiment, and the non-commissioned Officers as well. I do not think, therefore, that a subaltern instructor would be particularly required, though there are plenty of men who are quite fit to fill that office.

Then as to No. 4. The possibility of obtaining the services of two or three good lecturers on strategy and tactics to give lectures at different military stations, is only a question of making it worth their while, and I am sure that plenty of good men will come forward.

As to the Sandhurst grant. This having come to an end, Captain Tulloch suggests that it might be renewed in the form of Army Scholarships. He says the Government grant at Sandhurst was £20,000 when it ceased, but that was only of late years. Formerly, Sandhurst was entirely self-supporting, and did not take one farthing from the Government. If any money appeared to be voted, it

was only a matter of account. I think it would be very desirable to induce the Government to sanction scholarships for Officers' sons; but I am rather doubtful of success. I must say it has often been a matter of astonishment and regret to me, seeing that, in the Army, there have been many men of large fortune, they have not themselves endowed scholarships. I am sure it is from no want of generosity on their part, but simply because they have not thought of it. I have a suggestion to make which might be received more favourably than Captain Tulloch's proposal, namely, that it might not be a bad thing to give a few of the most earnest students in the Army some sort of exhibition allowance to last for a certain time, so that the men might go to foreign countries and make themselves thoroughly acquainted with the geography and resources of those countries, sending home periodical reports of the results of their observations. I have been long impressed with the desirability of devoting more attention to military geography than has been hitherto paid in this country. The Government do not seem to have felt that, and they have voted so very small an amount of money for the purpose, that it is impossible for the able Officers entrusted with the work to accomplish one-tenth of what they know to be necessary. We have often found, on going to war that there has been the greatest difficulty in getting interpreters and guides and people to give information as to the resources, the exchanges and so on of other countries; and we have been obliged to go into the high-ways and bye-ways to pick up men very ill informed, of no reputation, and possibly in the pay of the enemy. If some encouragement were given to the study of military geography, there would not be a country in the world with which we should not be thoroughly acquainted, and when the information was required, all that would be necessary would be to lay one's hand on the pigeon-hole and pull out the documents giving the information required. I do not see any particular advantage in enlarging Wellington College any more than any other college. The education given at that college is thoroughly general; in fact, I know it has been the great object of the late head-master to make it as little military as possible. There is nothing military about it, except the names of the passages—Wellington passage, Murray passage, Pakenham passage—that is the only thing military about the place. And, in fact, they seem rather to object to the boys seeing very much of their military neighbours at Sandhurst. I know that, in Prussia, the tendency has been for some years to make education more and more general before entering the Army and more special afterwards, and I think myself that special education before a young man enters the Army can only be theoretical, and can be but imperfectly mastered.

Then, as to the last point. I read only a few days ago a most able work giving an admirable scheme of military organization, &c., in which the author treads upon everybody's toes, and upsets everybody's interests. The scheme he lays down is, in my opinion, an extremely able one. It provides a solution for what is, after all, the greatest problem of the day, that is, the extension of our Army by giving provisional commissions to Officers of the Volunteers—not the Militia, because, according to his scheme, the Militia would be available for services in any part of the world in case of war—but for giving provisional commissions to the Officers of Volunteers to be held by them for seven years: this commission to be made permanent on war, and the holders being recognized Officers of the regiment as if they had entered in the ordinary way. With regard to the general question of military education, the great point, after all, is to make it worth the while of Officers to study. I have heard Officers say over and over again, "What is the use "of my studying? I am sometimes very much bored; I don't know what to do; "time hangs heavily on my hands; what shall I do?" I have recommended them to take up some branch of study, such as military art, and they replied, "What is "the use? I may be ever so good an Officer; but a subaltern never gets any "advantage from studying his profession." We might go a little further and say that Captains and Majors do not get any benefit from studying their profession. The great point, therefore, is to make it worth the while of Officers to study; and this is not to be done by giving certain prizes as the reward of mere theoretical competition, which only shows that a man has a certain number of undigested facts in his head, which he has not been able to assimilate, and which he could not apply.

The real practical stimulus would be to give professional advantage to those Officers who show that they know how to apply practically their military knowledge.

Captain E. ROGERS, Staff Officer of Pensioners, Longford: I rise with considerable diffidence to address this audience after the very able remarks by previous speakers on the excellent and truly suggestive lecture by Captain Tulloch. Certainly the instruction of Officers in the olden time was mythical, but who was to blame for it more than themselves? In my own regiment, the Colonel instituted a system of instruction by giving the details of the movements to be performed by the regiment on the following day, and also an intelligible critique on the performances of Officers and men the day before; and yet this book was irreverently called "the wanderings of an enthusiast." As regards the question of adjutants, I think that to add to the weight of their authority and responsibility they ought to be selected from among the captains, or at all events every captain and every subaltern of each regiment should be obliged to perform alternately the parade duties of adjutant, so as to get them thoroughly instructed in this portion of the departmental duties. Now, as regards Wellington College, I believe it partakes more of the character of an university than of a military academy. I do not know whether it is the case or not, but I should like to be informed whether this was originally intended by the charter when the College was first erected. There are surely educational establishments sufficient throughout the country without trenching on what ought to be our Army preserves. The sons of civilians who are educated at the College occupy the space and partake of the advantages which are due to the sons of retired Officers or Officers on half-pay. This evening, I had a conversation with an Officer whose nephew was educated at Wellington College, and on visiting it, he took very grave exception to the extravagance and luxurious style of the College in many ways. For instance, the boys provide their own furniture for their rooms, and where one boy could afford to furnish his rooms in an expensive manner, another could not do so, thereby raising and fostering a most invidious distinction very detrimental to discipline. This ought not to be. The days of military ignorance have, as your Lordship mentioned at the beginning, passed by, and every Officer, worthy of the name, is most anxious to be instructed in military matters, and to take advantage of that royal road to military learning afforded by the admirable institution of Garrison Instructors. I feel confident that if Captain Tulloch's suggestion be acted upon as to the appointment of special peripatetic professors, many will avail themselves of it in garrisons, hitherto shut out from the pale of military instruction, on the thousand and one questions of the hour, in which we are all so interested, and in which no country in the world should be so impressed as to their importance as our own. I have made only general remarks and have not gone through the questions *seriatim*, but I should like to know more about Wellington College from Captain Tulloch.

Sir THOMAS ACLAND: May I be allowed to put a question? I was not aware that we were at liberty to travel over the whole field of questions. I wish to allude to one of them. I did not mean to set up any very great exclusive merit for a classical education as against mathematical, far from it. I think one of the great faults of Eton has been, not that they do not teach mathematics, but that they do not make the boys learn. The drift of my remarks was that something like what they have in Prussia, is wanted, namely, that a boy shall not be taken to have had a public school education unless he is submitted to some kind of test when he leaves school, and that ought to include mathematics, possibly some physical science; but I still think a little Latin grammar, properly learnt, would be an advantage. It is the idleness of the boys, not the want of good teaching, that is in fault. I would not advocate classics; as an Englishman, I think the shortest way to learn your own language is to learn a little grammar, well and thoroughly. One word about the non-commissioned Officers. I am a Volunteer Officer, and have worked pretty hard both in the Yeomanry and Volunteer Services for many years. I think I have gone through all the elementary work and the practical part of teaching as far as we civilians can learn it. One great want is to get non-commissioned Officers who know how to teach. For myself, I have a

perfect model of a non-commissioned Officer as a man of character, therefore I do not speak as a burnt child, but still we want to establish a normal school for non-commissioned Officers and drill instructors generally. It is all very well for a man to know his business by heart, but if he does not know how to teach it, I should very much doubt his being a good adjutant or a good regimental sergeant-major. But that is not my business. I am, however, perfectly certain that he would make a good drill instructor of us Volunteers, because we have only at most about 24 hours in the year to learn drill, and the great art of teaching the auxiliary forces is to teach them in a short time. I need not appeal to those who know what drill instructors generally are, to say that they waste a great deal of time. I should be glad if this Institution would take up the subject and impress upon the Commander-in-Chief, that non-commissioned Officers must not only be taught and know their education by heart, but they must be instructed how to teach. Schoolmasters are not allowed to go into elementary schools unless they are trained to teach; it is not enough for them to know the globe or the catechism, but they must be able to impart their knowledge. I speak on this subject with some practical experience, and I hope the Army will take it up.

Lieutenant MAURICE, R.A., Instructor in Tactics, Royal Military College, Sandhurst: Speaking as one of the Officers engaged in the instruction at Sandhurst, I cannot venture to reply to Major Knollys' remarks, first, because I think it is absolutely essential in a discussion of this kind that one should confine one's self to the subjects strictly put before us, and secondly and chiefly, for the following reason:—Major Knollys' speech is a direct attack upon Sandhurst. Well, my Lord, with reference to that, our mouths are closed. The thing of all others which personally I am quite certain everybody engaged in the duties of the place would have wished, would have been that thorough public inquiry should have been made into the whole of the circumstances connected with Sandhurst. That inquiry has never been made, for reasons the soundness of which it is not difficult to understand, but with which we, at all events, have nothing to do. All I wish to point out is that as long as you only hear one side of the case, you must remember it is possible that there may be something to state in reply, I quite admit the force of Major Knollys' objections, as long as they are unanswered. But I would venture to suggest that objections are always apt to look unanswerable till they are answered. I came up here to-night, not to defend my own existence, so to say, but to give such experience as I have in relation to points to which the Lecturer has referred. There is one point on which our experience, I think, touched both the points which Sir Thomas Acland has brought forward in relation to the importance of leaving the selection of subjects in the hands of schoolmasters, and those which Captain Tulloch has brought forward in relation to the difficulties of instruction which he, and we, meet with, owing to the way in which men come to us from the public and other schools. Now I do think the accusation against the public schools, or rather against the education of the country generally, is precisely that which Sir Thomas Acland has alleged as an accusation against the non-commissioned Officers, and, I presume, to a certain extent against the Officers of the Army. What we complain of is not the subjects taught, but the method of teaching. It really matters to us very little what a man has been taught beforehand, for we have always to teach the special subjects ourselves; but this we do ask, that a man shall come to us who is in the habit of thinking, and who has not been so strained in his thinking that he shall look upon thinking as an awful operation, which is simply a matter of disgust to him. I confess I cannot express the cordiality with which I agree in what Sir Thomas Acland said about the importance of that part of the Eton education which is represented by boats and cricket, not in relation to the mere physical exercise, but in the training of thought and of mutual co-operation between men, which is connected with it. But I do think it is a terrible misfortune for our business, at all events that the sons of Eton should not more connect her in-door with her out-door teaching. I am not speaking of the picked men, but of the ordinary run of her men. What *we* have to do is, to give in-door teaching, which is *only* of value in so far as it is connected with the out-door teaching—with that very working of men with men. The whole point I find is this: a boy may, to put an, of course, exaggerated instance, know perfectly well that two and two make four, but try him with the datum, that there

are two men standing on parade, and there are two other men, and it will not occur to him that, as a matter of course, there are four men standing on parade. He has never been in the habit of considering that calculation, unless as a sum or an example, in which the men are as ideal as the figures. He has learnt it as a sort of thing which he has had to say by heart. Again, the test to which public schools are subject is entirely a different test to the one which we ought to set before ourselves. Public schools are tested by the number of Balliol scholars, the number of high wranglers, etc., whom they turn out. We do not attempt to turn out Napoleons and Wellingtons, for we cannot do it. The highest honours to be afterwards gained by those who come to us are not gained by mere instruction; but we require that no Officer should go from us who cannot use the commonest good sense in cases of difficulty. The complaint, I think, we should be disposed to make in relation to public schools, is that the tendency is to train the race-horses, and not to train the horses who are to do hard ordinary work. The whole force of the system is spent upon the showmen, and not upon the great body of the men. It is the great body of men who are important for our purposes. Mainly in relation to our special affairs at Sandhurst, is the mere preparation for the Officers who are to become the stock of the Army; all that we can do for them is to give them such information and training as will enable them, if they choose, to carry it on, and to learn anything else subsequently for themselves, and, as far as we can, to supply so much as that to *everybody*. But certainly with those who come to us, the mere training so simply, I think, has not been universal. Some of them are really afraid to put two and two together. I do not think you will arrive at what you want, by substituting arithmetic for classics. You must induce the habit of thinking, so that men may use their brains to some very small extent, just in so far as their brains will carry them, not to overstrain them, but that everything that is done should be a matter of thought, and not a matter of learning by rote. There is one other matter which Captain Tulloch has brought forward, on which I wish to speak, namely that in relation to the Reserve of Officers, because he and I suppose few others have a notion how the facts as to Sandhurst affect it. I do think it is a fact that wants thoroughly bringing forward, and which ought to be known about our College in connection with any discussion of the kind. Since the cadet system has been abolished, the effect has been, or will be in the next few years, to reduce the strength of the Army by something like 600 Officers, and for this reason. We are, I believe, to have something like a strength of 300 Officers at Sandhurst, going through their course of training. An equal number will always be undergoing their preliminary year. Every one of those Officers is reckoned on the strength of the Army. Not a single Sandhurst cadet ever used to be reckoned on the strength of the Army, but now, men who are taken absolutely for purposes of study, and who can by no possibility do any kind of regimental duty, are reckoned on the strength of, as if they were actually effective Officers doing duty with, their regiments. We talk about the small number of Officers in the Prussian Army, relative to the number of men, but there is not a single man reckoned in the Prussian Army, as effective, who is not doing duty with his regiment at the time. It simply makes the whole calculation absurd to ignore the facts as to whether you strike off 600 Officers or add them; you alter the whole calculation. A reserve of Officers in some way or other to be thrown into the Army as soon as war breaks out, is surely, as Captain Tulloch has urged so well, of the greatest importance. But before you enter into the calculation of how many and how effective Officers you could get from the Militia, you surely in the first place want that all those who are not really on the strength should not be reckoned at all. Every man who is not actually effective with the regiment should not be made to appear as if he were. Calculate your cadres in any manner you please, necessary for efficiency, but when you have them, let them be really what they pretend to be.

Major KNOLLYS: I beg to explain to the gentleman who has spoken with reference to Sandhurst, that my remarks do not apply in any shape whatever to the method in which the system is carried out, but only to the general idea, the original notion.

Lieutenant MAURICE: I did not mean to make the slightest remark reflecting on yourself, but merely to point out that there are moments when a scheme is in a merely experimental stage, and when the personal and general question becomes so intricately interwoven, that discussion cannot possibly be restricted to the general

question. Everybody must have heard what Mr. Cardwell said in the House the other day. The thing we should, from a personal point of view have wished, would have been an open inquiry. As soldiers, we are simply in the hands of His Royal Highness and Mr. Cardwell, but surely we may claim your indulgence when I say we think there may be something said in favour of the system. I do not think it is thoroughly understood that that is precisely the position in which the case stands. The question is in Mr. Cardwell's hands, not in ours. We have nothing to do but to leave it there. We are perfectly unable to say what might be advanced in defence of the scheme itself, because it would be impossible not to touch upon personal questions, which it seems right to those who know all the circumstances, and are responsible for the discussion, should not be entered upon.

Sir HARRY VERNEY, Bart., M.P.: I think that we are much indebted to the gentleman who brought this subject forward, and to those who have spoken upon it, because they are particularly qualified to give an opinion upon that which I take to be one of the most important questions in the Army, the having a sufficient number of young Officers ready in case of war, men who are highly instructed, and who possess every advantage that can be derived from the practice, together with the theory and study, of military affairs. I was struck with the difference of opinion expressed by Captain Tulloch and Major Knollys with regard to the question of instruction at Sandhurst, or with the regiments. It is desirable that Officers should not lose the practice of the Army, while they receive instruction, but it is the opinion of Garrison Instructors that they would be better instructed when away from their regiments. This is a matter of great importance, and should be brought under the attention of the Commander-in-Chief and of the Secretary of State for War for their decision. There is one department of the Royal Army, perhaps the most important of all, which appears to me to be very inadequately attended to. It is extraordinary that our Intelligence and Statistical Department is able to produce as much information as they have done on many occasions, when we consider of how small a body it consists. I believe there are not above six or seven Officers in that Department, whereas in the Prussian "grossen "General-stab" there are about forty Officers who are constantly sent there from different regiments, and who acquire a perfect information on the various subjects presented to them. When at Berlin a couple of years ago, I remarked the perfect information which that Department contained. It made me reflect, how very little, comparatively speaking, we possess. We went into one room which contained ample geographical and statistical information on the countries to the east of Prussia; another department dealt with countries to the south; and a third with the western frontier and countries beyond it to the west. The Officer accompanying us said, "Now "would you like to see some of the maps which we send to each battalion taking the "field?" I said, "Certainly, very much." He said, "Where would you like to see "them? Name any part." I said, "I have just come from Sedan, and should like to "see that country, which I have visited." He took down a set of maps from a pigeonhole, a bundle of 25 or 30, all upon linen, each map containing about 12 or 15 square miles. The woods and rivers were marked on it; every village, every stream, and the lines of hills in the neighbourhood. That bundle was to be sent to one battalion, and when the battalion leaves that part of the country they send back the maps and have another set of maps, 25 or 30, of the next district, giving a perfectly accurate description. That is a practice which we ought to adopt, and we might have it at a comparatively small expense. It is not that we have not sufficient Officers, but that Officers are not employed in getting that information which would give us the greatest advantage to achieve successes in war. Perhaps I am rather wandering from the question, which I understand to be, what should be the education of young men in the Army and of young Officers? I recollect an Officer who used to send his son to ride across the country, and then say, "Now sit down and "make me a sketch of the country you have been riding over. Tell me what hill "will command another. Point out to me how you think military manœuvres "might be carried on in this line of country, how a hill or line could be de-"fended or attacked." For a young man going into the Army, that is a very desirable sort of instruction, extremely interesting to him, as well as valuable in a professional view, and which might be given at a military

college. I was sorry when Sandhurst was abolished, I was there two years, as well as three at Harrow, and I thought at the time, and I think still, that every Cadet who became an under-Officer was perfectly fit to go on active service against an enemy after he had joined his regiment a week, if he had taken advantage of the instruction afforded at Sandhurst. We were there taught military drawing on the most perfect and complete system then known; we learned quite enough of field fortification to enable us to command a company in war, and to throw up hasty earth-works, and also a certain amount of regimental drill. As has been so well said by those who preceded me, what you want in the Army and everywhere else is the exercise of the mind and the formation of character. By this competitive system, you may judge of men's intellectual capabilities, but you do not develop their characters, and it is character you want to command men, and for everything else in this country. We are particularly fortunate in having heard the opinions of those who have been engaged in this very pursuit, and I am sure any of us who are acquainted with what Sir Thomas Acland has done in his own neighbourhood will receive with great respect, and consider with attention, the suggestions he has made. I hope our sitting this evening will not terminate without hearing other gentlemen speak, who, like Lieutenant Maurice, have given their minds to this subject, because, after all, the important thing is to hear from men of thought and experience, and from some younger men, what they think most desirable for the education of Officers of the present day. It is to young men that we must look, and we value the opinion of those among them who have given their minds to their work and learned to take an intelligent interest in their profession.

Lieutenant W. H. James, R.E.: As a young Officer who wishes instruction, may I be permitted to make a few remarks? First of all as to the subject of field fortification, it has been said that young Officers do not know what field fortification is. Now, when I was passing, one of the examiners himself had not the faintest notion of the difference between a covered way and a double sap. He asked the question what a covered way was, and he thought it was a double sap.

With regard to public school education, it is pretty well admitted that hitherto it has to a certain extent failed in providing the necessary amount of educational training for Officers.* I think the London University admit this to some extent by their late rule omitting Greek from the matriculation examination. There is no doubt that most public schoolmen know nothing at all of Greek and Latin which they have spent the best years of their life in learning. Could I have, over again, the years which I unfortunately had to give to Latin and Greek, to devote to French and modern languages, I should have a chance of knowing much more than I can now possibly acquire. With regard to the next suggestion, there is a plan which is found to work well in India, and that is, offering rewards for passing in native languages. I believe a similar institution in England would be a good thing. Men passing in modern languages should receive a reward either in the shape of qualification for employment, or some remuneration for the time and money they must necessarily have spent in learning the language. I think some such plan would be found to work very well. There is another system followed out in Prussia, and that is, sending Officers on foreign tours. We all know that the information in the statistical department in the Prussian Army is entirely derived from sending Officers into countries in time of peace. All sorts of stories have been told in the newspapers about photographers in the Vosges mountains and in other parts of France previous to the late war. If we are to obtain information as to other countries, we must follow the Prussian example, and to do it, we must spend money.

C. E. H. Vincent, Esq., late Royal Welsh Fusiliers: It was, my Lord, very late this evening, when I heard of this meeting, but I can only rejoice that the notice came in my way, for otherwise I should have lost much sound instruction from the paper of the gallant lecturer, and from the remarks of the Officers and gentlemen who have spoken on the subject thereof.

Captain Tulloch and Major Knollys appear to take great exception to the public

* Owing to the fact that so much valuable time is wasted in acquiring the *most faint smattering* of Greek and Latin.

school education of England, as exemplified in the Officers of the Army. But, my Lord, I think you will agree with me when I venture to point out to them that the aim of public school training is not in the direction of the profession of arms; it is rather a general education on which can be subsequently built the speciality an individual requires. In this country, it is not customary, and happily so, to fix definitely upon a walk in life, at the early age when foreign parents call upon their children to come to a final decision respecting their course in maturer years. Therefore it is impossible for us to conduct elementary training in any specific groove. In Prussia, the young man who is going into the Army usually selects that career from the very first, and, entering the Cadet College at 10 years of age, his boyish days never witness any departure from a fixed method of training. In that military nation, the result, indeed, is satisfactory; but is it desirable for us to engraft the military despotism which there reigns supreme, into our free and extended institutions? If not, then how could geometry or the subjects which the garrison instructors present wish to have their pupils instructed in before they fall into their hands, be introduced into the public school system without infringing on its general character? Sir Thomas Acland instanced the high education of the Prussian "Einjährige Freiwillige." May be they do take precedence of our Sub-Lieutenants, but so they should do in their own interest, for a gladiator, in the intellectual arena of civil life, cannot be placed in the same category as the professional soldier. The "Einjährige," I must remind the hon. baronet, are not aspirants to military honours. They avail themselves of the one-year system only to free their necks from the military yoke in time of peace.

As regards the element of modern languages, it is, without doubt, of the utmost importance to give it greater prominence in all education, and this is being done; but for it to expel classics *in toto* from the field, would again infringe on the general system. The point of English composition and arithmetic is, perhaps, the most weighty in the discussion paper. That the former is terribly neglected is notorious and self-evident from even the most limited private correspondence. Were a high standard insisted on in all public examinations, the masters of schools would not be slow in turning attention to the subject. In respect to arithmetic, I should have thought a very respectable knowledge of it was actually necessary to pass any examination; but, be that as it may, no standard, however high, could infallibly keep equations in the head of Officers, and, as I understood one speaker, it was mainly the ignorance in this subject that he deplored.

The paper, in my hand, asks whether it would not be desirable to replace regimental instruction by one or two central schools. Does not the area over which our Army is scattered answer the question in the negative? With the concentrated army of Prussia, you can have concentrated schools, but with us, that hateful word "expense," must prevent it. Are we not all more or less interested in the reduction of national expenditure, with its coincident and identical diminution in the burden of taxation? None of you, gentlemen, can be anxious to increase the expenditure of the country, unless it is likely to give increased efficiency, and this the proposal holds out little hopes of. Were it adopted, with our army quartered all over the world, the locomotion of every rank would be no less endless than costly.

As to whether non-commissioned Officers ought to be more technically educated, few will give a dissenting vote; but I must venture to protest against the idea that another subaltern should be struck off the duty-roster. Officers of companies would look upon it as an obligation and a privilege to perform. Already, specialities bring regimental duty on a few only, and in addition to this evil, the soldier is disassociated from his immediate superior, which must be unfavourably looked on by all. The other questions as to Wellington College, &c., exceed my scope, even more than those I have already touched upon. I cannot, however, my Lord, sit down without saying one word more for the admirable public school system of England, with its general purpose, its unique moral and physical training. Does any Englishman wish us to sacrifice these for the severe discipline, slavery of mind and body, and comparatively narrow range of continental education? Surely, my Lord, it cannot be.

Sir HARRY VERNEY: A friend of mine was taken prisoner by Napoleon, about the

time of the battle of Marengo. Napoleon kept him a fortnight, and found him to be a very nice young fellow, who had lately left College. I said to him "What did Napoleon talk most to you about?" "Oh," he said, "he asked me over and over again upon two points; there was nothing, he said, that he wanted to introduce so much into France as our public school system, and our country gentlemen." He said those were the two points on which over and over again, day after day, Napoleon asked for information.

Captain TULLOCH (in reply): As regards the education of public schools, there is one thing, Greek, which I do not think need be so much taught to men not intended for College, and in that opinion, I consider, I am borne out by every one who has spoken on the subject in this Institution. Latin unquestionably is all very well; the Prussians omit Greek in all their examinations, but they retain Latin. With reference to the moral training of our public schools, I am sure there is no Officer in the Service but regards it with the very highest veneration. In the Navy, I observe the question of obtaining boys from public schools has been brought forward, and Admiral Ryder, in a paper on the Education of Naval Officers, says,—"Patronage "to first appointments in all public offices is being swept away. There can be no "reason why the Admiralty should not follow as regards the Navy afloat, but with "proper precautions. Let us assume that the First Lord is prepared to give up his "patronage, which many have considered a perfect nuisance, but says, as he may "well and rightly say, 'I will not consent unless the new scheme secures that the "'boys be, as a rule, gentlemen—that is, lads who have been brought up by and "'associated from their earliest years with persons who are recognized as gentlemen "'and ladies.' How can this be done? I say it can be done by aid of the *public "schools*. I doubt if it can be secured in any other way." Admiral Ryder then goes on to propose that the nominations to compete for naval cadetships (Queen's Cadets excepted) should be given to the public schools, according to the number of boys educated at each. With Admiral Ryder's view, I venture to agree most thoroughly, and wish much that such a scheme were possible for the Army; but as regards the education which some boys get at certain public schools, I can hardly call it such, although the indoor work goes by that name; the evidence given before the Royal Commission on military education corresponds exactly with my own experience on this subject. The examiner in history and English, speaking of the examinations when they first commenced, says,—"I remember when the Archbishop of Dublin and "I examined 150 candidates, we only found 15 who were qualified at all: in fact "there was the greatest possible ignorance. There was no such thing as a standard, "and any answers we got were perfectly accidental." So much for public school education there. Touching the other more general points, another witness, a Colonel commanding a regiment said, "One of the defects was the want of sufficient attention "to the handwriting of candidates (Officers), which is sometimes so bad that, were "they soldiers in the ranks, I should hesitate to permit them to be non-commissioned "Officers, and in connection with the same subject, I may observe that it often "happens that young Officers display great difficulty in expressing themselves cor-"rectly in writing." The classical examiner, speaking in 1868, says,—"Formerly "men came, and you could not understand why they presented themselves at all "for examination, for they knew nothing; the number of such men has diminished." The Commissioners say to him, "You expected that taking young men who had "received a public school education, you would have found them more competent?" "It was astonishing to me how they could know so little." The mathematical examiner, in answer to a question, says, "I do not think that the public schools of "the country generally prepare all the youths who come from them with so much "mathematics as we require." "What is the amount of mathematics required?" "Very little." Further on, in answer to a question, he says, "Supposing that he (the "candidate) had to get his marks out of arithmetic alone, I think that there are "many boys in a first-class national school who would get the marks." With such evidence on public school education, I cannot think it may be said to be education at least as far as the boys who come into the Army are concerned. With reference to what Major Knollys said on garrison instructors lecturing on strategy and tactics, and their having time to do so, I only hope they may have sufficient time but at present they decidedly have not.

Major KNOLLYS: I spoke of the future.

Captain TULLOCH: The fact of a number of young fellows being at Sandhurst together is no objection to my proposition for having instruction carried out there, as they would be mixed up with a number of older Officers, and the whole scheme would be conducted as a garrison instruction class is now. Sandhurst was self-supporting only during a period when the Army estimates were cut down so unsparingly; when military education, and nearly everything else connected with the Service was withering under the blight of false economy, for which the nation paid so dearly in the Crimea. In the historical notice of the Military College, by Captain Hozier, given in the Appendix of the Report of the Royal Commission on Military Education, the Royal warrant states, "that the College is also intended to afford a "provision for the sons of meritorious Officers who have fallen or been disabled in "the service of their country, and the means of education to the sons of those "Officers who belong to our regular service." The old College of Sandhurst was undoubtedly a very great boon to the Service; Officers' sons were cheaply educated there. The new College has no more to do with the past College than that had to do with Hythe or Shoeburyness. The present College is under a new arrangement altogether, and the amount granted for the College just before the old order of things was brought to an end was a direct benefit to the Army: of this they have now been deprived.

As regards what Major Knollys said on Wellington College, I quite agree that education should be entirely general before entering the Service, and special afterwards. If a boy learnt what he might learn, there is no question but that his time would be fully occupied in his work at school; he would be taught his military subjects very much better when he joins the Service. Civilians and military men who have studied the subject are, I believe, all of one mind on that point, viz., that professional subjects should *not* be taught at school.

With reference to what Captain Rogers said about Wellington College, there is a feeling in the Army that the place is not as closely allied to the Service as it ought to be, considering that the Army were called upon to subscribe to it. The nation also subscribed to it as an Institution for the education of Officers' sons. I believe, in the first instance, it was intended for orphans, but surely if it is capable of giving a home to others than orphans, the rest of the College should be turned to account for Army purposes. Sons of Officers generally have to fight their way very hard in the world, and if they are associated with civilians' sons who may be extravagant in their ideas, as they certainly appear to be by the account given this evening, and I am strongly inclined to think that they are so even from the prospectus of Wellington College itself, the Officers' sons will be none the better for associating with boys richer than themselves. How it is that civilians get into Wellington College, and why are they there? I know not. If money is wanted for the College, and the case were properly represented, it could be got. The Army might subscribe again if the College were brought into closer alliance with it.

Sir Thomas Acland said that they do not make people learn sufficiently at Eton, and in that defect of public school education I venture to agree most perfectly. Boys who are wilfully idle are not compelled to work, but are allowed to do just as they choose. Over and over again I have asked my pupils about the different colleges. "So you were at ———?" "Yes, I was at ———." "What "did you do there?" "Oh, if I wished to work there were people to teach me, but if "I did not exert myself there was no compulsion whatever." What Lieutenant Maurice has said so entirely agrees with my own views that I need say nothing further on that head.

I will just refer to what the last speaker, Lieutenant Vincent, remarked about public school education being general. He states that if you teach geometry you would affect the general character of the school. The boys have plenty of time to amuse themselves, and to learn something as well, that is in addition to stringing together Latin verses, which appear to be about the principal occupation in some schools, *vide* letter from a public schoolmaster, Report of Military Education Commission, Appendix, page xxiii. In arithmetic, there is decided room for improvement. Certainly from the specimens I have seen of English composition from young Officers, the sooner greater pressure is put on schoolmasters to teach it the

better. With reference to the question of foreign service being against the establishment of the proposed schools of instruction, of course the present system of garrison instruction would have to be carried on till the proposed schools were in regular working order. Then as every Sub-Lieutenant would go to one of the schools before he went abroad, there would be no necessity for foreign instruction at all. If a subaltern is to be struck off duty, he would have, as a matter of course, to be made a supernumerary in the same way as the adjutant.

In conclusion, my Lord and gentlemen, I can only thank you for the very kind way in which you have listened to what I fear has been a tedious lecture, and I only hope that the discussion this evening will have some effect in drawing attention to the matter I have brought before you.

The CHAIRMAN: I suppose there will be great difference of opinion on some of the points brought forward, but there will be none I am sure on what I am about to propose, which is the thanks of the meeting to our gallant Lecturer for the very able discourse of the evening, and the extensive information he has given us.

Evening Meeting.

Monday, June 30th, 1873.

VICE-ADMIRAL SIR FREDERICK W. E. NICOLSON, Bart., C.B., Vice-President, in the Chair.

ON THE GAME OF NAVAL TACTICS.

By Lieut. W. M. F. CASTLE, R.N.

ON my arrival in England, a short time ago, I was much surprised to find that my name was connected with a "Naval War Game." I did not realise the great responsibility that my friends had incurred for me, and the great difficulties to be overcome, until I obtained the "Rules of the Conduct of the War Game," published by Captain Baring, R.A. I can hardly express my feeling after the perusal of these rules, for I saw at once that this "Land War Game" was the result of many years deep thought and hard work, and that my attempt at a "Game of Naval Tactics" can only bring us to the outline of a subject, so deep in its development, so complicated in its details.

However, having received an invitation from the Council of this Institution to read a paper on the progress that I had made in my game, I am here this evening, feeling how unworthy any effort of mine must be to add anything to the development of a science still in its infancy; but I hope that my endeavours to work out many of the details, will meet with the careful and lenient consideration of those who are interested in the movements of fleets, whether for the defence of our country, or the keeping up of that unparalleled historic name, which has been gained in a great measure through the vigilance, self-denial, intelligence, and hardihood of our seamen.

In explaining this game, I must ask you to place yourselves this evening in the position of a Commander intrusted with the command of a fleet during war. Your first study would then be to ascertain the steaming, the turning, and the fighting power of your ships, the object to be accomplished, the number and general character of your enemy; these are facts required in playing this game. Each player having digested them, he then forms a general idea of the power, &c., of the respective fleets, and in his dispositions will proceed as his

judgment directs. Any knowledge as to the ability of the opponent would also be useful, as it would enable him to use discretion in the performance of a hazardous strategic movement.

Should we be embroiled with a Foreign Power, not only would it be necessary to defend our own coast line, but it would be also necessary to afford protection to our colonies; under such circumstances the necessity of a thorough knowledge of the winds, prevailing currents of the ocean, coast line, accessible ports, facilities for coaling, and of numerous other facts indispensable to complete efficiency in a Commander-in-Chief and his staff, must be patent to any person who has given a thought in that direction.

We all know what weight a few well directed blows, aimed surely and scientifically, have in the result of mortal combat. So, in order that the leaders of our future fleets may strike boldly and surely, knowledge of the various powers and resources of the enemy must form an important element in the character of the attack. The Admiral must have the clearest possible conception of the power of each individual ship, and unbounded confidence in the ability of his captains, who in their turn should be animated by an *esprit de corps*, and a spirit of chivalrous respect for their Commander.

To be an active and efficient tactician would be of little worth, if the quality of a strategist be wanting, as I imagine the former would have only a small field, if any, to display his powers, if deficient in the latter quality. Therefore, I think I am right in saying, that to be a successful tactician, one ought to be a good strategist. The power of finding your opponent, meeting him at the greatest advantage to yourself and at the greatest disadvantage to him, involves weighty considerations, arrangements, and forethought. Such considerations, too, as in the day of battle, ought not to be left to the "chapter of accidents," which I much fear would be increased should any Commander be guilty of such indiscretion. For, instead of adding fresh laurels to those already so nobly won, England's naval glory would, I fear, be tarnished, and the historic reputation which at the beginning of this century adorned the annals of our Navy, would be sadly overshadowed. It is for this reason that I hope the consideration of this important subject may be facilitated in some small degree, if only by familiarising those who study their profession with the terminology and method of naval evolutions.

Should England be called upon to withstand invasion, I am of opinion that a numerous fleet of light draught, heavily-armed vessels of moderate speed would be most necessary and useful for the defence of our shores. As we already possess such a fleet, I shall pass them over without further allusion, and proceed to consider what part our ironclad, ocean-cruising fleet might be called upon to play. England's vital point is to be found elsewhere than upon our own coast line. She is dependent on her Colonies and merchant navy for the luxuries, aye, even the necessaries, of life. Were we engaged, therefore, with a naval Power of any pretensions whatever, it would not only be necessary to have a large fleet to insure free access to the Channel, and so render safe the arrival and departure of our merchant fleets,

but we should also have to keep a very careful eye in the direction of our great Colonies—Australia and New Zealand; for it is in these directions I think we have most to dread. Our colonists themselves are not altogether blind to this eventuality. Melbourne has set the example of buying heavy ironclad turret ships to protect her coast line. At this present moment Sydney has devised a very fair system of submarine mine defence. A young but intelligent colonial Navy is being trained, not for mere vanity, but looking forward, with that farsightedness which has so distinguished the plodding, thriving colonies, to the time when England being attacked through them, they must bear their part in defence of fatherland.

Considering these facts, and that in all probability the scene of glory for the Royal Navy will not hereafter be confined more to our own shores than during former wars, I proceed to explain the game, hoping that my humble endeavours to work out the necessary details will meet with your kindest consideration.

I cannot lay sole claim to the idea of this game, for it was proposed to me by an old messmate* several years ago, his idea being to move little blocks, representing ships, over a chart placed on the ward-room table; the idea soon dropped, but the very great success of the German KRIEG-SPIEL, and the invitation to express my ideas before the members of this Institution, led me to attempt the working out of the proposed game during the few unemployed hours at my disposal.

The strategic portion of this game may be carried out on the ordinary chart, such as is supplied to ships, for it is nothing more than a problem. Given certain facts with regard to the single relative and collective power of ships, coal-carrying capabilities, proximity or otherwise of land, season of the year, object to be accomplished, points at which mails are to be intercepted, stations at which colliers are to be met, and a host of various other details, a knowledge of which would add to the confidence of the Commander in the arrangements made at home for the efficiency of his squadron: these are the data. An acquaintance with them is indispensable to prevent embarrassing disappointments, which tend to affect the morale of a squadron longing to render a good account of the expected enemy.

"The Game of Naval Tactics" is not a study of fancy moves, and imaginary formations, for I have devised it for use in connection with the General Signal Book; and, to be played to any real purpose, the game requires great patience and attention, strict adherence to the rules laid down, and also great accuracy on the part of the players. Thus each move and consequent change of position is studied with as much care as if real squadrons were being manœuvred. In fact, we must try to assure ourselves of the practical character of the circumstances as laid down in the problem to be worked out.

I have chosen for convenience, as I shall show presently, a square space enclosed by lines representing 16 nautical miles in length. This space is of convenient size, as it is capable of representing an area enclosed by 16, 8, or 4 nautical miles. This change of scale can be

* The Rev. Fred. Davies, M.A.

made at pleasure, and will be found convenient at certain stages of the game. Thus when a series of movements have been made by both squadrons, but, owing to the smallness of the scale and the proximity of the ships, the space is found to be insufficient, both parties may agree in suggesting to the umpire that the whole area be taken as representing a space enclosed by lines 8 or 4 instead of 16 miles in length, and the position of the ships can then be relaid and the game continued. This change of scale will be convenient, as it will make the effect of the different movements more perceptible. The advantage of the larger scale will be seen should two ships be so placed with regard to each other that ramming is imminent.

Again, a chart representing the small scale area will also represent the distance at sea, at which vessels would be out of sight of each other. I have experienced much difficulty in arranging a scale large enough to represent the track of a ship, or leading ship of a squadron or division, when altering course any number of points to starboard or port; but I have adopted the scale shown as the nearest and most sufficiently exact measurement for that purpose. Many experiments have been tried at various times during evolutionary cruizes to measure the diameters of the circles made by ships when turning completely round at various speeds, and I think it has been generally accepted that the modern type of ironclad makes a complete circle, the diameter of which is about three and a half times their length. The circle is not, however, quite complete, as the ship generally finishes slightly inside the original starting point.

Another difficulty presented itself,—the very great difference in length between ships of the various classes which would probably form the line of battle. During the autumn of 1869, the combined fleets, consisting of the Channel and Mediterranean Squadrons, with the Admiralty Flag flying at the "Agincourt's" main, were cruising off the mouth of the River Tagus; each class of ironclad ship was represented in this squadron, and each varied considerably in length. I have, therefore, for the present, struck a convenient average—300 feet.

Another difficulty arises from the difference of the diameters of the circles made by the various ships when turning. Some have balanced rudders, others ordinary ones, and some, perhaps, rudders moved by Rear-Admiral Inglefield's hydraulic steering gear.

Owing to the complications that would have arisen in making many different scales to represent the turning arc of each class of ships, under various speeds, I have taken 8 knots as the average speed at which a ship moves through the water when turning. Although I have named this speed, the player is at liberty to suppose any other he may consider most consistent with the data previously laid down.

It may appear to many that I have spoken rather indefinitely on the before-mentioned points. I have not, however, had access to any official records of turning circles, except those of the Channel Squadron during the autumn of 1867, but I have obtained much trustworthy information from Captain Colomb's papers published in the journals of this Institution, more particularly from his paper on "Modern Naval Tactics." For reduction of speed during turning, I have taken the "Bellerophon,"

a ship of 300 feet, as an average example, and I find that her speed, when steaming 12 knots, was reduced when actually turning, to nearly 8 knots an hour. This and a similar experiment made by the "Lord Warden" at 10 knots, I think justify me in considering 8 knots as about the average speed a ship makes when turning a circle. I have not thought it necessary to trouble the meeting with any speeds under 10 knots.

The object of the game is to facilitate the study of the evolutions, laid down in our present Evolutionary Signal-Book; and to familiarise Officers with the mode of performing them; with the time and space that a few combinations must occupy; and with the points to be attended to or to be avoided in actual practice.

It may be thought that a method of showing by scale the various movements of a squadron of ships is unnecessary, prior to contact with the enemy, since, with steam, so long as we can hold our fleet in hand, and have it ready, a host of preliminary evolutions may be superfluous. Some Officers of known experience are of opinion that on sighting an enemy, it is only necessary to form groups, that is, pelotons of three or four ships, and attack the wings, avoiding the main body, and when a suitable distance to their rear, to retrace one's steps and prepare to repeat the same tactics; others prefer the old line of battle. But a Commander-in-Chief may have other objects in view,—he may be weak, he may expect assistance and support from a friendly force, perhaps dispersed for the purpose of gaining information of the enemy, and it may be necessary to postpone a general and bold advance. His objects in delaying the fight may be many, but still these are not the points I wish to bring before you this evening, for I take it for granted that the various evolutions, illustrated in the Signal-Book, have each their special intention.*

In the preliminary arrangements of the game, it is open to the students or players to decide at what speed the circles should be described by the whole squadron, but I have taken 8 knots, as I said before, as the average speed in turning. It is, however, always possible to arrange the scale for any speed that circumstances may require and the position will admit. It rests with the students to select from an imaginary fleet the description of ships they prefer to form their squadrons, say, so many "Devastations," "Cyclops," "Sultans," "Vanguards," "Monarchs," or "Glasgows."

I do not intend this evening to bring the squadron into actual contact, but explain the principles on which the game is founded, hoping that, should a discussion follow this paper, I may learn something practical, which will prove of assistance in the further development of this game. I will now proceed to read the rules, and explanations of the various tables, scales, &c.

The Playing Board (Plate I).

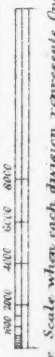
The board on which this game is played is 64 inches by 64 inches. Lines are drawn 4 inches apart across the board from side to side, and

* Since this was written, I have learnt that a great change is about to take place in the "Evolutionary Signal Book."

Playing Board.

1/4 inch to 4 inches or 1 Nautical Mile.

Side Scale when Two divisions represent One Nautical Mile.

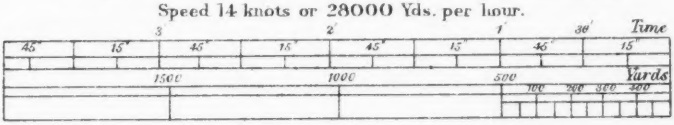


Side Scale when each division represents One Nautical Mile

SCALE I.

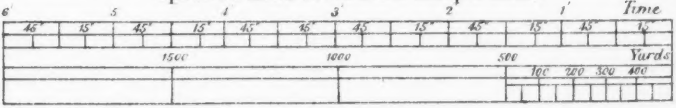
To be used when each Division on the Board represent One Nautical Mile

Speed 14 knots or 28000 Yds. per hour.

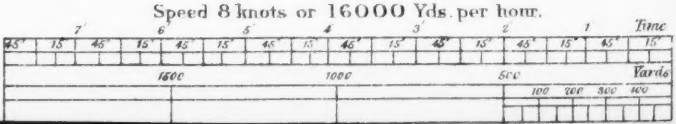


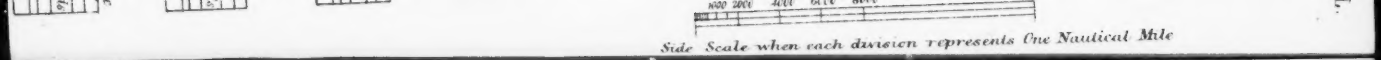
Speed 12 knots or 24000 Yds. per hour.

Speed 10 knots or 20000 Yds. per hour.



Speed 8 knots or 16000 Yds. per hour.



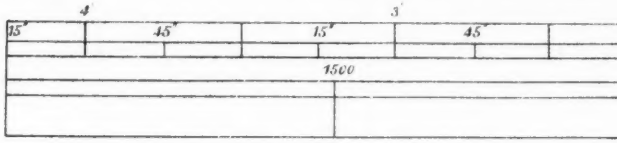


Side Scale when each division represents One Nautical Mile

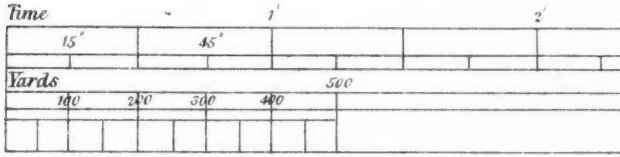
To be used when Two Divisions o

PLATE I.

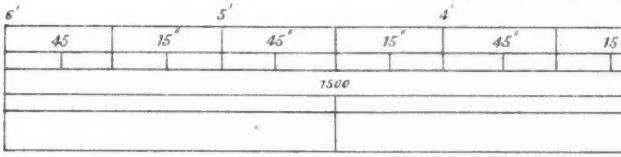
Speed 14 knots



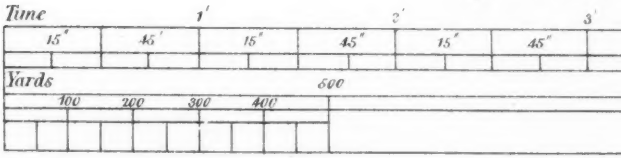
Speed 12 knots



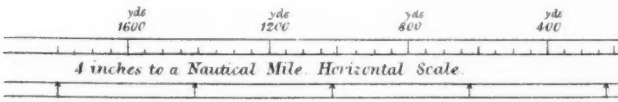
Speed 10 knots

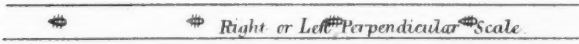


Speed 9 knots



Horizo

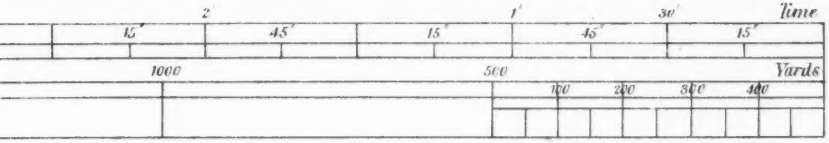




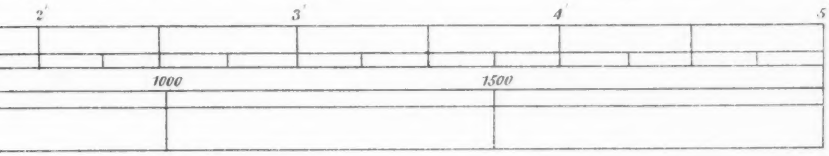
SCALE II.

Divisions on the Board represent One Nautical Mile. PI.XLI

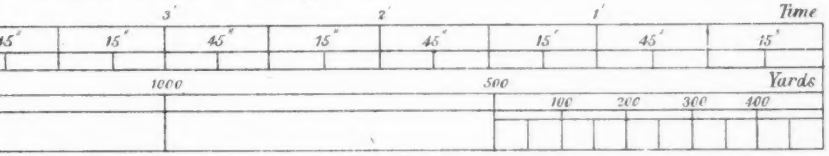
ed 14 knots or 28000 Yds. per.



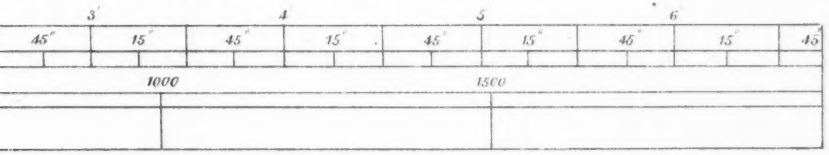
ed 12 knots or 24000 Yds. per hour.



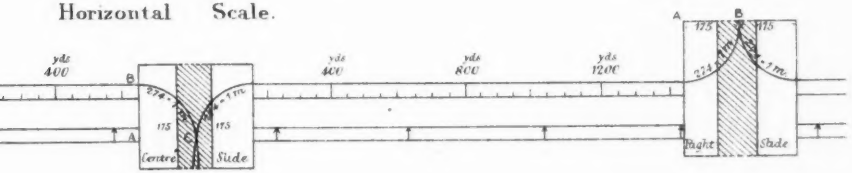
d 10 knots or 20000 Yds per hour.



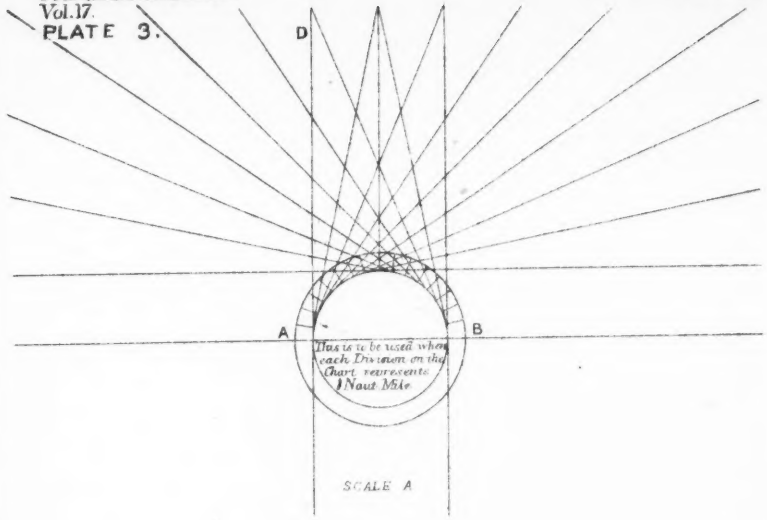
ed 9 knots or 18000 Yds. per hour.



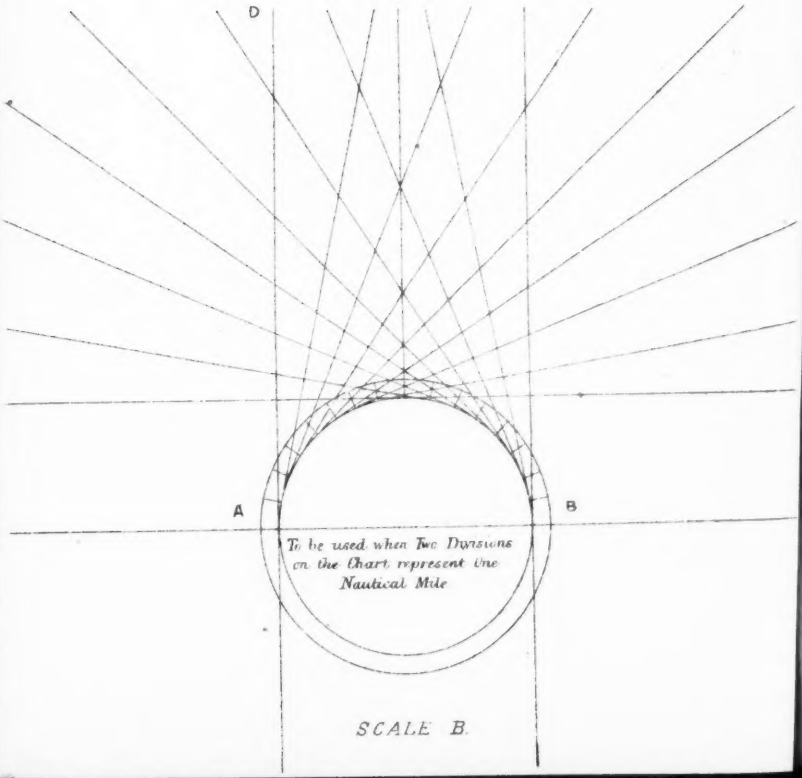
Horizontal Scale.



r Scale



SCALE A



SCALE B.

also others at right angles to these lines. The distance between each pair of lines represents 2,000 yards, or a nautical mile. In order to facilitate the counting of the several divisions, every alternate line is drawn in red ink. The board therefore represents a space enclosed by lines 16 nautical miles in length; or it may represent a space enclosed by lines 8 nautical miles in length. Again, it may represent a space bounded by lines representing 4 nautical miles; in this case *four* divisions represent one nautical mile.

The scale on the left side of the board represents the nautical mile 4 inches in length; it is divided into divisions of 500, 100, and 50 yards. On the right side of the board is a scale representing the nautical mile 8 inches in length; the scale is divided as the other.

The board, for convenience of packing and general use, is made up of 16 blocks of paper, each block being 16 inches square and 12 sheets of paper thick, on the same principle as a drawing block, so that when one surface of paper has been used, it can be removed and the board be ready for a new game.

The markers for noting the position of the ship upon the playing board are made of thin flat lead; the distinguishing colour and fleet number of the ship they are intended to represent, is fastened to them,—a pin secured to the body of the marker, facilitates its manipulation. The markers are made a convenient size, but should it be necessary on the playing board to represent the exact dimensions of a ship, an outline may be drawn to the scale of the unit that the board represents, viz., on the full sized board ·19 of an inch, when two divisions represent 1 nautical mile ·38 of an inch, when four divisions represent 1 nautical mile ·76 of an inch in length.

The leaders of each squadron bears a flag, either RED or BLUE, fastened to the head of the pin.

Scales 1, 2 *and* 3 (Plates I and II).

Scale 1, Plate I, represents four different speeds, viz., 14, 12, 10 and 8 knots, and is used on the full-sized board for measuring the distances corresponding to certain times. The lower edge is marked in yards, the upper edge in minutes and seconds; so that, when a certain distance has been run, the time occupied is easily found, or, if a ship has moved at a known speed for a certain number of minutes, the corresponding distance can be found.

Scale 2, Plate II, is on the same principle as Scale 1, and is to be used when TWO divisions on the board represent ONE nautical mile.

Scale 3, if constructed, would be on the same principle as Scales 1 and 2, and would be used when FOUR divisions on the board represent one nautical mile.

Altering Course Scales (Plate III).

SCALE A to be used in combination with SCALE 1, *i.e.*, when each division on the board represent one nautical mile. The scale is constructed on the following principle: suppose the average length of the

representative class of ironclad to be 300 feet, and that her speed when turning a circle is reduced to 8 knots. The average diameter of this circle being $3\frac{1}{2}$ times her length. The number of yards described in the circumference of the circle may be easily calculated—

$$\text{thus } 3{\cdot}5 \times 100 \times 3{\cdot}1416 = 1099 \text{ yards (about).}$$

Dividing this circumference by 32, the number of yards contained in each compass point is found. Table B, has been constructed on this data.

SCALES B and C are constructed on the same principle as SCALE A just explained, and would be used when *two* or *four* divisions on the board represent respectively one nautical mile.

When altering course ONE or ANY number of points to starboard, select either of the scales, A, B or C, according to the unit of measurement in use; place the left hand corner *A* so that the horizontal line A B touches the stern of the ship; the line A D in the same line as her course; count off the required number of points to the right (for instance, 5 points), follow the line radiating from this point of compass to the board, there make another pencil mark, then remove the scale, and join these two points. The line joining these two points will represent the new course of the ship.

Horizontal Scale (Plate II).

A most useful scale for all rectangular formations.

A separate scale of this description is required for each unit of measurement. They are divided into three parts, viz., horizontal bar, slides, and perpendicular scales. The horizontal bar is about 12 inches long; the upper edge is divided from the centre at each 50 yards; the lower scale is divided from the centre at each 400 yards; the divisions on the latter scale are called CORRECTION MARKS. The right or centre slide is adjusted to either of these correction marks; according to the distance the columns are to be apart when moving from SINGLE COLUMN in line ahead to COLUMNS OF DIVISIONS in line ahead. An example of its use will be given later in this paper.

The indentations on the perpendicular scale represent ships; they are each 400 yards apart. A few other ordinary scales are required, such as a long straight edge, parallel rulers, and a box of mathematical instruments.

TABLE A.

Table A. This table shows the NUMBER of yards a vessel will pass over the water in calm weather during a known time at a known speed. Its use requires little explanation; it would be principally used when measuring long distances. Knowing the time a ship proceeds in a direct course, and the speed, the DISTANCE is easily found. For instance, moving at 10 knots per hour for ten minutes, the distance by Table A = 3,333 yards. To measure this distance on the Playing Board (Plate I) refer to the *side scales*.

TABLE A.—*Distance in Yards that a Ship moves at a given speed during a given time.*

Knots.	m. 60	m. 50	m. 40	m. 30	m. 20	m. 10	m. 9	m. 8	m. 7	m. 6	m. 5	m. 4	m. 3	m. 2	m. 1	sec. 45	sec. 30	sec. 15	sec. 10	sec. 5
14.....	28,000	23,330	18,664	14,000	9,332	4,666	4,200	3,932	3,282	2,800	2,333	1,866	1,400	933	466	358	233	116	76	38
13.....	26,000	21,667	17,335	13,000	8,666	4,333	3,900	3,467	3,033	2,600	2,166	1,733	1,300	866	433	324	216	108	72	36
12.....	24,000	20,000	16,000	12,000	8,000	4,000	3,600	3,200	2,800	2,400	2,000	1,600	1,200	800	400	300	200	100	66	33
11.....	22,000	18,330	14,666	11,000	7,333	3,666	3,333	2,933	2,582	2,222	1,833	1,466	1,111	733	366	273	183	91	61	30
10.....	20,000	16,667	13,332	10,000	6,666	3,333	3,000	2,666	2,331	2,000	1,666	1,333	1,000	666	333	249	166	83	54	27
9.....	18,000	15,000	12,000	9,000	6,000	3,000	2,700	2,400	2,100	1,800	1,500	1,200	900	600	300	225	150	75	50	25
8.....	16,000	13,330	10,666	8,000	5,333	2,666	2,400	2,133	1,882	1,600	1,333	1,066	800	533	266	198	133	66	44	22
7.....	14,000	11,665	9,332	7,000	4,666	2,333	2,100	1,966	1,641	1,400	1,166	933	700	466	233	179	116	58	38	19
6.....	12,000	10,000	8,000	6,000	4,000	2,000	1,800	1,600	1,400	1,200	1,000	800	600	400	200	150	100	50	33	16
5.....	10,000	8,333	6,666	5,000	3,333	1,666	1,500	1,333	1,165	1,000	833	666	500	333	166	124	83	41	27	13
4.....	8,000	6,665	5,333	4,000	2,666	1,333	1,200	1,066	941	800	666	533	400	266	133	96	66	33	22	11
3.....	6,000	5,000	4,000	3,000	2,000	1,000	900	800	700	600	500	400	300	200	100	75	50	25	16	8
2.....	4,000	3,332	2,666	2,000	1,333	666	600	533	470	400	333	266	200	133	66	48	33	16	11	5
1.....	2,000	1,666	1,333	1,000	666	333	300	266	235	200	166	133	100	66	33	24	16	8	5·5	2·5

Table B.

Table B gives the *time* and *distance* in which a ship will describe a *whole circle or any portion of it* when the helm is put to starboard or port, and is based on the experiments carried out by the Channel Squadron off the coast of Portugal, 6th and 7th November, 1867. This table will be always used when changing course; for instance, alter course 5 points to starboard, time occupied by Table B = 38 seconds.

Portion of circle.	Distance.	Time.
		min. sec.
32 points.....	1,090 yards.	4 7
16 „	545 „	2 3·5
8 „	272 „	1 1·7
7 „	238 „	0 53
6 „	204 „	0 46
5 „	170 „	0 38
4 „	136 „	0 30
3 „	102 „	0 23
2 „	68 „	0 15
1 „	34 „	0 7·7

Table C.

Table C shows the *time* which a column of ships will take to form *columns* of *threes* from LINE AHEAD at different speeds.

Knots.	6.	7.	8.	9.	10.	11.	12.
	min.	min.	min.	min.	min.	min.	
12.....	2·83	3·23	3·86	5·24	7·82	15·47	
11.....	3·25	3·91	5·28	7·84	15·49		
10.....	4·03	5·30	7·86	15·52			
9.....	5·32	7·88	15·54				
8.....	7·93	15·56					
7.....	15·60						
6.....							

The tables are all constructed on the same principle.

In Table C, the upper line of figures in each table represents the speed of the leading ship; the figures in the side column, the speed of the vessel which has to move over the longest distance. To use this table, suppose the speed of the leading ship or column to be 6 knots, the speed of the ship which has to steam over the longest distance to be 9 knots; by entering Table C along the top column, with the speed of the leader, and the side column with the speed of the last ship, the time required, viz., 5·32 minutes, is found.

Or again, for example, suppose the Fleet to have been steaming in ONE or MORE columns in line ahead at 10 knots, and the signal is made for columns of THREES, the leader reduces his speed from 10 knots to 6; the rear ship has a small reserve speed, and consequently steams 11 knots, then by Table C the time is found to be 3·25 minutes.

TABLE D.

Table D shows the time which a column of three ships will take to form *groups* from LINE AHEAD at different speeds.

Knots.	6.	7.	8.	9.	10.	11.	12.
	min.	min.	min.	min.	min.	min.	
12.....	1·08	1·22	1·42	1·73	2·38	3·94	
11.....	1·26	1·45	1·79	2·42	4·02		
10.....	1·5	1·82	2·45	4·29			
9.....	1·89	2·52	4·36				
8.....	2·6	4·45					
7.....	4·6						
6.....							

TABLE E.

Table E shows the time that six ships may form the *indented line*, from COLUMNS OF DIVISIONS IN LINE AHEAD, at various speeds; ships in close order.

Knots.	6.	7.	8.	9.	10.	11.	12.
	min.	min.	min.	min.	min.	min.	
12.....	2·31	2·36	2·45	2·57	2·78	3·14	
11.....	2·55	2·65	2·76	2·98	3·38		
10.....	2·85	2·93	3·22	3·66			
9.....	3·26	3·54	4·00				
8.....	3·86	4·39					
7.....	4·91						
6.....							

TABLE F.

Table F shows the time that six ships may form the *indented line* from COLUMNS OF DIVISIONS IN LINE ABREAST at various speeds; ships in close order.

Knots.	6.	7.	8.	9.	10.	11.	12.
	min.	min.	min.	min.	min.	min.	
12.....	4·62	5·5	6·89	9·15	13·69	26·9	
11.....	5·53	6·9	9·16	13·7	27·0		
10.....	6·91	9·17	13·71	27·1			
9.....	9·19	13·73	27·2				
8.....	13·74	27·3					
7.....	27·4						
6.....							

General Rule for use.—Enter the upper column of knots with the speed of the leader of division, the side column of knots with the speed of the ship which has to pass over the longest distance, and the corresponding time is found.

Appended to this paper are the equations by which these tables have been formed.

Should this "Game of Naval Tactics" find few friends, yet I hope that these little tables may prove useful, for if embodied in the Evolutionary Signal-Book, they might be used as a guide, when performing evolutions in actual practice.

TABLE G.

Table G shows the DISTANCE in yards that the last ship of a fleet, when steaming in SINGLE COLUMN IN LINE ahead, will have to steam over, to take her new station *in line abreast*. To use this table, enter the *side* column with the fleet number of the last ship, the top column with the order (close or open), then refer to Table A with the known speed and known distance, and *the time* for the evolution is found.

No. of Ships.	Close order.	Open order.	Remarks.
	Yards.	Yards.	
2.....	565	1,130	
3.....	1,130	2,260	
4.....	1,697	3,390	
5.....	2,260	4,520	
6.....	2,828	5,650	
7.....	3,493	6,780	

Rules for the Students or Players.

The students to consist of five persons, viz., one umpire, two principal players and two assistants,—the principal players are to name all moves. Each move to count for two minutes of time. The principal players will be furnished with several slips of papers (Form 1), on which they will communicate their intentions in writing to the umpire. Each player writing in a different coloured ink.

FORM 1.

Colour of player.	Number of moves demanded.	Evolution.	Speed.	Remarks.	Times, &c.
					h. m. Players' entry.. Umpire's „ .. Termination of evolutions ....

A player may claim five moves at one time. He may claim a new move before the move that he is making is finished; but this move cannot be commenced until the time for the last movement has expired. Should a player, in writing his intention, fail to use the terminology of the Signal-Book, the mistake should at once be called attention to by the umpire, who will delay the execution of the movement half a move (*i.e.*, one minute); this is most important, as in practice any mistake in signals delays the evolution and causes endless confusion. During delays the ships will continue to move on in their original formation.

Should a player wish to increase or decrease the speed of his ships, he may do so two knots, by telling the umpire and the assistant player of his own side his intention; but should he wish to proceed at such an increase of speed as would in actual practice entail more boiler power, he must claim ten moves, communicating his intention to the umpire in the usual manner.

The umpire's decision under all circumstances is to be final. He should furnish the leading players with a special idea, written distinctly on paper, naming the object to be accomplished, the time allowed for the execution of this duty, the place at which coals may be procured, mails met, reinforcements found, ports that have to be closed; those that have to be defended, extent of cruising ground, proximity of land or shoal water, strength of the opposing force, their position on a certain date; in fact he must supply each player with as much intelligence as would probably be communicated to the commander of a squadron ordered away to form a portion of a combination. He will keep an account of the moves made by each player on Form 2.

After having registered the move demanded, as will presently be explained, the umpire will give the player's assistant the slip of paper (Form 1), in order that the movement on the board may be marked off. No move is to be made until one move (two minutes) has elapsed since the receipt of the notice. The umpire must check any undue haste on the part of the players, and prevent either making too many moves in advance. He must prevent talking or observations by either side which will hint to either party any information; he may stop

the game whenever he may think it necessary in order that the assistant players may mark up the relative position of each squadron. After stopping the game, the umpire may limit the number of moves; this will be found necessary when the opposing ships are in close proximity. On the receipt of the slip of paper (Form 1) from the principal player, the umpire should note the interval of one move upon it, and then pass the paper to the assistant player. For instance, Red at 10h. 14m. demands three moves; under the time entered by the player, the umpire notes the interval of one move, also the time for completing the evolution, in the following manner:—Form 1, players' entry 10h. 14m., umpire's 10h. 16m., evolution finished (three moves for evolution) 10h. 22m.

FORM 2.—REGISTER OF MOVES.

Form 2 illustrates the table in which the Umpire keeps the record of the moves.

RED.				BLUE.			
Move column.	Hour.	Evolution.	Remarks.	Move column.	Hour.	Evolution.	Remarks.
1	1	A.M.		1	1	A.M.	
2	2			2	2		
3	3			3	3		
4	4			4	4		
5	5			5	5		
6	6			6	6		
7	7			7	7		
8	8			8	8		
9	9			9	9		
10	10			10	10		
11	11			11	11		
12	12			12	12		
13	1	P.M.		13	1	P.M.	
14	2			14	2		
15	3			15	3		
16	4			16	4		
17	5			17	5		
18	6			18	6		
19	7			19	7		
20	8			20	8		
21	9			21	9		
22	10			22	10		
23	11			23	11		
24	12			24	12		
25				25			
26				26			
27				27			
28				28			
29				29			
30				30			

RED'S moves are registered in the left columns.

BLUE'S moves in the right columns.

The column numbered from 1 to 30, is arranged for recording moves, two minutes to each move; the column numbered from 1 to 12 a.m., and 1 to 12 p.m., for recording the hour; the "evolution" column for recording the evolutions; "remark" column for remarks.

Suppose we wish to register a move, commencing at 10h. 14m. a.m., place a pin bearing the colour of the player in square 10 of hour column, this registers 10 hours; place another pin in 7 square (move column), this registers the minutes, viz., 14m. Supposing the player to claim 3 moves, the umpire places another pin in square 11, thus registering the one move imposed by the umpire (as was before explained) and the number of moves demanded, viz., 3. By this means we have registered 10h. 14m.; also 10h. 22m., the former being the time at which the evolution was commenced, the latter the time when the evolution is finished; any remarks that the umpire may think necessary should also be entered.

Should the umpire impose the fine of half a move (that is 1 minute), the minutes in the move column, if previously even, will become odd; when marking odd minutes, place the pin on the line between the squares in "move" column.

Since the registering of seconds would involve some complication, the nearest minute must be taken, or dice may decide whether it shall be the minute just elapsed, or the next in advance.

By these means the umpire regulates the moves, and checks a player making too many moves in advance, or getting too many moves in arrear of his antagonist.

The record of blue is kept precisely in the same manner.

RELATIVE SPEED TABLE FOR SAILING SHIPS.

Since ships, whether ironclad or otherwise, may cruise under sail, it is necessary that the umpire should have some rules furnished him for treating such cases.

Ships under sail, with the wind free, may be supposed to move with greater speed than those close hauled.

Description of Vessel.	Force of wind.	On a wind.	Free.	Remarks.
		Knots.	Knots.	
Frigates (wood cased or otherwise)	4 to 6	5	7	This table represents the speed of ships under ordinary conditions. The umpire must state all circumstances of the weather, if ships are under sail, when he names the time of sighting one another.
Ironclads.....	,,	4	6	

Under ordinary circumstances, the umpire may allow 16 minutes for a fleet to prepare for action, and to have steam ready for 8 knots.

Example of the Use of the Horizontal Scale. (Plate II).

Suppose fleet in single column in line ahead.

The player of the red squadron intends FORMING COLUMNS OF DIVISIONS IN LINE AHEAD, ships turning to starboard (Plate IV).

The player hands the slip of paper (Form 1) to the umpire, correctly written up (as previously explained); this represents the signal being hoisted. The umpire detains the paper and adds to it, the interval of one move, then passes it on to the assistant player. (This represents the signal being hauled down.)

The assistant player first selects the horizontal scales for the unit of measurement, and places the centre slide immediately over the position of the leading ship; the horizontal scale being at right angles to her course. He then moves the right slide to the third correction mark, and transfers the position of the right division to the playing-board. The position of the left division may be marked off by measurement, each ship abreast of her opposite neighbour. In order to find the time that this evolution will take to perform, the assistant-player refers to Table B for the time of two changes of course at right angles, viz., 2 m. 1 sec.; he next counts the number of hundred yards between the inner edge of the centre and right slide, viz., 850 yards. Then suppose speed of ship to be 8 knots, 850 yards at 8 knots = 3 m. 12 sec.; whole time occupied in performing evolution = 5 m. 13 sec.

Example of the Use of Tables C and D.

I have classified Columns of Threes and Groups under the same head.

Tables C and D give the least time that these evolutions can be performed under the most favourable circumstances, at various speeds; in actual steam evolutions these tables would be of little use, except as a reference and a guide. But in playing this game, since the umpire may decide the practicability of any evolution, it necessitates some exact data to start upon.

Fleet in COLUMNS OF DIVISIONS IN LINE AHEAD, Diagram 1, Plate V, to form columns of THREES.—The player of the red writes on paper (Form 1), in red ink, the number of moves he demands, the movement he intends making, viz., form columns of threes. Leader reduces speed to 6 knots, wing ships increase speed to 9 knots, three moves. The umpire then records, in Form 2, red's time and moves demanded, and hands the signal to the assistant, who carries it into execution. The assistant-player, on reference to Table C according to rule, finds that the time this evolution will occupy is 5 m. 51 sec.; he then refers to Table A, 5 m. 51 sec. at 9 knots = 1,750 yards.

To lay off this distance on the Playing-Board (Plate I), draw a line 1,750 yards in length from the position of the rear ship in the column, 282·8 yards to the right of her original course as in the Diagram

From Line Ahead to Columns of Divisions in Line Ahead.

PLATE 4.

From Line Ahead to Line Abreast.

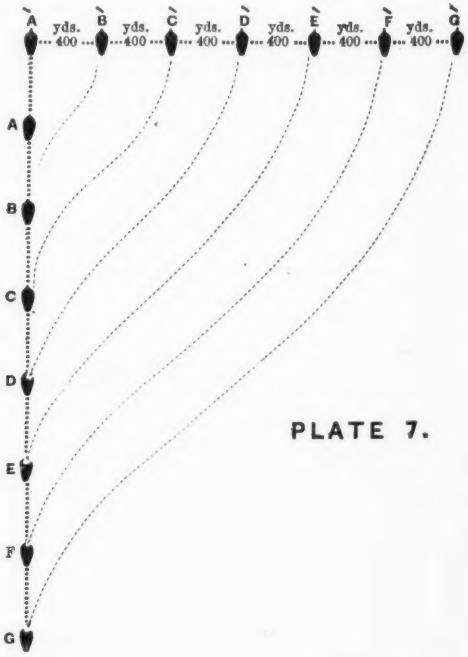


PLATE 7.

Columns of Three's from Line Ahead. Groups from Line Ahead.

PLATE 5.

DIAGRAM 1.

From Columns in Line Ahead to Indented Line.

DIAGRAM 2.

From Columns in Line Abreast to Indented Line.

PLATE 6.

DIAGRAM 1.

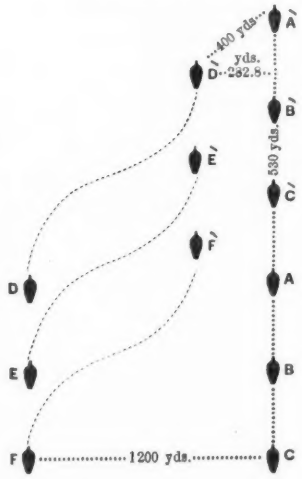


DIAGRAM 2.

1, Plate V. (A) is the position of the leader, (B) the left wing ship, (C) the right wing ship. With a very little practice the assistant-player would learn to make these movements very quickly.

A few seconds will elapse after the completion of this movement before the time (three moves) claimed for it, has expired. If no move has been previously demanded, the columns of threes will continue to move on in the original direction.

The same rules are applicable for group formation (Diagram 2, Plate V), and therefore will not require any explanation.

The next formation provided for is FORMING THE INDENTED LINE, from DIVISIONS IN LINE AHEAD (Plate VI, diag. 1). Table E is constructed to facilitate this movement. Supposing the fleet to be moving at the speed of 6 knots, and either player wishes to form the indented line, the player gives the umpire the slip of paper (Form 1), stating his intention; this slip of paper is handed to the assistant player in the usual manner. Supposing the left division to have an excess of speed of 2 knots. Then on reference to Table E, it will be found that the least time in which this evolution can be performed, is 3·86 minutes; now lay off the new position of the leader of the right division, at 6 knots per hour during 3·86 minutes, and place the leader of the left division 400 yards distant and 4 points on the right leader's quarter; the remaining ships will be placed in their respective positions.

When reforming column in line ahead from this formation, Table E may again be used.

If, again, the fleet be in TWO COLUMNS IN LINE ABREAST (Plate VI, diag. 2), and it is wished TO FORM THE INDENTED LINE, the number of ships in each division being three, the player acts as before, the assistant player refers to Table F, and ascertains the time; for instance, leading division steaming 6 knots, the rear division has an excess of speed of 3 knots, their time by Table F = 9·19 minutes; lay off on the Board (Plate II) the distance at 6 knots during 9·19 minutes, and protract the positions of the remaining ships.

Again, suppose the fleet to be moving in SINGLE COLUMN in LINE AHEAD, and a broader front is required, for instance, to form SINGLE COLUMN in line ABREAST (Plate VII). This evolution will be expedited by the leading ship reducing her speed to steerage way, the remaining ships moving by the shortest road to their new front, when there take up the speed of the wing ship; when all are in line abreast they increase speed together. To ascertain the time and distance, refer to Table G for distance; enter Table A with the distance found and speed of the last ship, and you find the required time.

Having spoken of the evolutions which treat exclusively of changing formations, we next come to a series of evolutions such as changing directions of columns; columns of bow and quarter lines, &c. These evolutions I propose to treat much in the same manner as the before-mentioned ones; for this purpose, tables must be computed on the same principle as Tables C and D, and with a little ingenuity on the part of the assistant players, any of these movements may be plotted down on the playing-board.

Altering the course of columns, preserving the formation of the fleet,

either when in columns, in line ahead, or in line abreast, and preserving bearing and distance, present difficulties, which at present I have not endeavoured to overcome, but I imagine that should opportunity occur, the time for these evolutions at different speeds and with various numbers of ships, might be noted. These times would be generally useful in supplying data for this game.

With reference to "stationing," I do not think that it is necessary to enter into an explanation as, I take it, that such evolutions would not be attempted in the presence of an enemy.

In conclusion:—I wish to be thoroughly understood, that this game can never take the place of experience. I do not pretend that it will be useful, to those who are already experts in the art of manœuvring ships. I only hope that it may be useful to those, who have not had the great advantage of schooling in evolutionary squadrons, also to those who intend making naval tactics a portion of professional study.

There is one point that I am anxious to dwell upon. I believe that I am right in saying, that at present no facility whatever for the study of tactical formations is given by the authorities to the Officers in command of ships by furnishing them with the turning curves made by steam-ships on their trials. The turning curve of each ship should be tabulated and supplied to each vessel for the use of the Officers. Another point we are deficient in is the absence of an authorised "manual of naval tactics" which could be procured by Officers desirous of studying this important subject. We ought to have a tactical drill book similar to the Army Light Infantry Drill Book—a book procurable at the nearest stationer's shop. If a naval man has a taste for military manœuvres, he can study to his heart's content every branch of the "Land War Game," but there are no helps whatever in the study of Naval Tactics.

Perhaps I have laid myself open to censure in that I have not brought before you to-night, the method of performing all the movements given in the Evolutionary Signal-Book. Time has not permitted my entering into them all, but I have endeavoured to treat a portion of them thoroughly, in order that it may be seen that the remaining evolutions are susceptible of similar treatment.

In making these explanations, I am to a certain extent restricted from quoting the Evolutionary Signal-Book, but I sincerely hope that I have not trespassed on its "confidential" character.

I have only spoken of the elementary, but, I am inclined to think, most useful evolutions, avoiding questions of rams, guns, or towing torpedoes; for until this game is accepted in its simpler form, I think it would be unwise to introduce the consideration of various offensive arms, which would in their varied uses add fresh complications.

I feel sure that all present this evening, recognise the necessity of some such assistance in exact tactical studies as, under the name of a game, I have endeavoured to explain. Should the game only be studied occasionally by a few Officers, it will bring imaginary opposing squadrons into tactical contact with each other. This must raise discussion which will assist to fix the limits of practicable plans and

ideas in the heads of those who interest themselves in the science of naval evolutions and tactics.

General Formulæ by which the Results shown in the foregoing Tables C, D, E, and F, may be found.

In each case let a yds. = distance passed over by fastest ship in 1 min.
b = „ „ „ slowest „ „
and n = Nos. of minutes.

To Construct Table C.

$$a^2n^2 = 400^2 + (800 + nb)^2 - 2(800 + nb)400 \times \cos. 45^\circ$$
$$= 16000 + 640000 + n^2b^2 - 452480 + 565{\cdot}6\, bn$$
$$a^2n^2 = 347520 - 1034\, bn + n^2b^2$$
$$n^2 + \frac{b \times 1034}{a^2 - b^2}\, n = \frac{347520}{a^2 - b^2}$$
$$n^2 + \frac{b \times 1034}{(a - b)(a + b)}\, n = \frac{347520}{(a + b)(a - b)}$$

Equation for Table D.

$$n^2 - \frac{b \times 234{\cdot}4}{(a + b)(a - b)}\, n = \frac{93760}{(a + b)(a - b)}$$

Table E.

$$n^2 + \frac{b \times 566{\cdot}}{(a + b)(a - b)}\, n = \frac{920978}{(a + b)(a - b)}$$

Table F.

$$n^2 - \frac{b \times 1834{\cdot}4}{(a + b)(a - b)}\, n = \frac{921280}{(a + b)(a - b)}$$

Lieutenant Brown, R.N.: I should like to ask the lecturer, as no arms are used by the ships, what is the ultimate issue of the game as played between the two players according to the present rules, I mean, what influences the decision of the umpire with respect to the various ships and the ultimate issue of the game?

Lieutenant Castle: I am rather afraid that Lieutenant Brown has mistaken what I wished to convey to the meeting. What I have been working at for some time, is to show what I have shown you this evening. I have not attempted—nor do I intend to attempt, until I have worked through the whole of the Evolutionary Signal-Book and really fought this battle—to enter into the subject of the power of one ship against the other when fighting. There is one point that, before I come to actual contact, I should be glad to mention. I have taken average diameters, and average circles, average lengths of vessels, and average speeds. That is all very well indeed on the playing-board; but when we come to the disposition of the fleets with regard to each other, and there is no time to make signals, then, I think, the curves that I spoke of just now (the curves that I thought were so necessary to be supplied to each ship, of the turning powers of various vessels) may be used with very great advantage. It appears to me that the climax of what is to be done at present, is to bring the squadrons into contact with one another. We ought to have some pre-arranged plan, so that, if we attack in a formation, on

arriving within a certain distance, we should have some definite idea of the individual work of each ship. That will be the conclusion which, ultimately, we shall arrive at. Of course, there are several courses open. We may have several separate flags for separate movements. One flag would be the signal to engage, or to alter the course four points to starboard, or to port, or to pass through line, or on the right of the line, or on the left of the line. Wherever I have played this game, these are the points that we have always argued about. I have not the power at present of deciding which ship will have the advantage when in actual contact. One man would say, "My guns will penetrate your armour." Another will say, "My armour will "resist your guns;" and all this provokes discussion. I do not think, at the present moment, that I am prepared to discuss with anybody that portion of the game. At the same time, I think, it is very easy indeed for the umpire to decide which, in his opinion, has the best position at the commencement of the attack. You might leave it to him, at any rate, to say who is in the most favourable position.

Lieutenant BROWN: I meant it is the business of the umpire at the conclusion of the game to decide, when the two fleets are brought within a distance when no more signals can be made, which fleet is in the best position for attack. (Lieutenant CASTLE: That is my object.) The curves in Plate 3 have been calculated for an average length of 300 feet for each ship? (Lieutenant CASTLE: Yes.) Have the two extremes of the longest and shortest ships been tried to see what difference the length would make according to the scale on the chart on which you propose to work out the plan; have you always assumed that same average during the game?

Lieutenant CASTLE: Just so.

Lieutenant BROWN: Have you ever tried the game on the quarter scale?

Lieutenant CASTLE: No, I have not; and I do not put much faith in it. It might be necessary when you are within 200 yards of each other, and when you come to fight with individual ships; but otherwise I do not put much faith in it. It would only be necessary when you come to fighting individual vessels within 200 yards of each other.

Captain WHEATLEY, R.N.: Are the same tactics applied to vessels with end-on fire as for broadside fire?

Lieutenant CASTLE: I have merely taken the Signal Book as my basis to start from, working the fleet evolutions as they are given for our use, taking them for what they are worth. I thought it was the only way of playing my game.

Captain CODRINGTON, R.N.: Do you play the game irrespective of time, like the moves on a chess-board?

Lieutenant CASTLE: Time is the essential point of the game.

Captain CODRINGTON: Then the moves would be behind the signals?

Lieutenant CASTLE: Not exactly.

Captain CODRINGTON: I do not see how, in using these scales and manipulating the models of the ships on the board, you would actually put your fleet in the same position in the same time that a smart hand would hoist a signal?

Lieutenant CASTLE: I do not want to. When I have played my game, I have been two hours in thinking over moves that really occupied 38 minutes. There is no object in moving quickly. When you arrive at some formation, you consider what is to be done next; there is no hurry about it.

Commander ANSON, R.N.: My difficulty was with ships with double screws. Supposing you suddenly stopped or reversed your engines, or one engine or the other engine, it would be important to lay that down on the table.

Lieutenant CASTLE: I do not think double screws would have very much to do with it. You might reasonably, if you are steaming 10 knots, take 3 moves—6 minutes, or 4 moves—8 minutes in a general way. I do not think it would much affect the principle of my game.

Captain COLOMB, R.N.: I am unfortunate in having missed the reading of the paper; but I see at once that there are differences of opinion; and, out of these differences of opinion, we should always get a certain amount of truth. There is no question whatever that the endeavour must be a good one—whether it be well done or ill done—the endeavour is one of those things which is perfectly certain to produce other endeavours. The lecturer having taken it up seriously must have gone a certain length with it. Whether he has begun wrongly or rightly, I cannot say; but

the Officers present who heard the paper, and that very much larger number, including myself, who will hereafter read it carefully, are quite certain to get ideas which will carry them farther; either they will avoid what appear to them to be errors, or they will make advances in the other direction. When I met the lecturer at Portsmouth the other day, he spoke to me about the tables I see. They are quite irrespective of any game of the kind proposed, and the value of such tables is very great in all the movements of our fleets, in those which are proposed to be retained, and in those which are to be condemned; because the great element for their retention or condemnation, is the *time* occupied in performing them. Now, any single individual asked to pass judgment upon any of these different movements might not always have the means of so doing at his disposal; and the Lecturer having taken the trouble to go through the movements and to calculate, as he has done for different speeds, the amount of time that each movement would take, puts a great deal into the hands of naval Officers that they had not in their hands before—a great deal of excellent stuff that is very useful, and that can be applied at once. As to the general question of the War Game, my difficulty has been, that whereas in the Army what is a disadvantage and what is an advantage, is perfectly understood and known, and has been tried by the experiment of war, as far as the Navy is concerned, we are actually *in nubibus* as to what are advantages and disadvantages. Therefore, if the game is in the nature of the military war game, I cannot quite understand how it is to be decided which has won. In point of fact, whether you may not credit a man with having won—for doing something which further experiment and further consideration would show is just what he ought not to have done. I am bound however, to say, when I mentioned it to the Lecturer at Portsmouth, he told me that that point hardly entered into his proposal.

Captain BURGESS: I should like to ask Lieutenant Castle how many games he has played, and whether the Officers who played them were generally satisfied?

Lieutenant CASTLE: I have played four games; and the general idea amongst my messmates was that we were a long time making our moves. We took two hours in our final game to get over a time of 38 minutes. Suddenly we brought our squadrons within 800 yards of each other; and then came the knotty point as to who had the advantage. A discussion followed. Instead of the Umpire giving a final decision, every one present argued the point for themselves. The result was, that the next day none of us were satisfied. This game provoked an immense deal of discussion—a thing that had seldom been provoked before. It provoked so much discussion that I think it really led to uncommonly good results, and it was ultimately decided by the Commander of ship, which fleet was in the best position.

The CHAIRMAN: The difficulty which has just been partly answered is the one that I feel. It is this: that after all these manœuvres I cannot see how it can be an easy task for the Umpire to decide who has the advantage. Whether they are 800 or 400 yards apart, the question as to the final decision is then to arise. It is a very different thing in the *Krieg-spiel* as played in the Army, because the whole thing is based upon very different data, and data that are so clear and so easily ascertainable with regard to the movements of troops over roads and over country, and so on. I must say, there seem to me almost insuperable difficulties in carrying this game out to an issue that will really be practically useful; but still, at the same time, it is quite evident that anything that turns the minds of Officers to think about tactics, and the time and the manner in which ships are to be moved, and that, in addition, has the advantage of these tables to which Captain Colomb has alluded, must be useful. I think, therefore, we are very much indebted to Lieutenant Castle for bringing this subject before us—a subject extremely novel to most of us; and I may say I am only expressing the sense of the meeting in returning him our thanks for having brought it forward. I may go further and say we trust that he and others who take an interest in this matter, will work it out, and, at some future time, bring the subject again before us in a more complete state. I cannot help feeling that, at present, we are only on the threshold of a very difficult and complicated question, which may, in the end, be extremely useful to the Naval Service in general. I, therefore, with your permission, will return our thanks to Lieutenant Castle.

EXTRACTS FROM A REPORT ON ORANGE WALK, NEW RIVER, AS A MILITARY POSITION FOR THE PROTECTION OF BRITISH INTERESTS IN HONDURAS; WITH NOTES AND EXPERIENCES ON OUT-POST DUTIES IN "THE BUSH."

Communicated by Lieut. J. E. Bale, 1st W. I. Regt., Garrison Adjutant, Jamaica.

Population.

This small settlement has a fluctuating population, may be from 300 or 400 inhabitants, on the average, the majority half-breeds, between the American Indians of the adjacent tribes and the descendants of Old Spain, long located on this portion of America, a few English artificers, or waifs and strays from over-crowded towns, who develop, from surrounding pressure and incidents, into useful hands, as carpenters, wheelwrights, smiths, and jobbing builders, &c.

Native Buildings.

The Indians are expert and ingenious in making their huts, or more properly, houses of hut materials, for they truss and frame their roofs on sound architectural principles, using only well-selected, naturally grown poles and timbers, which they bind or lash together with "tie tie," a strong fibrous parasite or vine, made pliable as rope by soaking in water; when dry, it keeps the whole firmly in position, and the roof is thatched with palms, using the stems of the leaf to hold it on the rafters and laths, in a complete and uniform manner. The butt of the principals is a natural fork, sometimes kept from splitting by interlaced "tie tie;" the walls are made of pimentos, small palm trunks, placed vertically side by side, and plastered with marl within and without. All the above they do without using a single nail or even a peg of wood. The floor is usually of marl, pounded down hard.

Water Transport.

The produce from the estates, also merchandise from Belize to the different stations, is conveyed by schooners or bongys (old Spanish bonga, a boat), along the river and the sea passage within the reefs and bays to Belize.

Road Communication.

Roads, so called, are, with the exception of short distances from or around a settlement, impracticable for carriage traffic, and the bridle roads are merely tracks through the primeval forest and across portions of lagoons, and quite impassable during a rainy period; the rains, however, are partial most of the year, so that no correct idea can be formed of roads at a distance, unless by traversing them often; a cart

road exists to Trial Farm, 1½ miles north of Orange Walk, and another to Tower Hill estate, to the south about four miles.

Rivers—Lagoons.

The rivers are slow, even sluggish, very tortuous, frequently forming a letter S in a distance of half a mile, generally deep, with steep banks, or fringed with mangroves growing to a height of 30 to 50 feet for miles together; many savannahs open out from these rivers; lagoons are numerous, and many are of considerable extent, and are mostly impassable.

Climate.

The sun is as usually felt in the tropics, and in addition to its rays, there is a great glare of reflected light and heat from the marly ground, when not overgrown with grass and weeds. A great change of temperature takes place at night during the winter months, the thermometer sometimes registers as low as 58° or 59° during the prevalence of the "Northers."

If rain falls, or has lately fallen, the whole country is chill and damp, with dense vapours or fogs, which wet the clothes and hair, and chill the frames of people exposed at night, and especially so just before day dawn: these mists often last up to 10 or 11 o'clock, A.M., when they change, through the sun's power, to oppressive, hot vapour, till dispelled by evaporation.

Troops and Mercantile Influences and Results—Hardy Qualities of the Indians—Specialities of African Troops for Bush Service.

The mercantile and trading element at Belize has much influence, through the Members of Council, in ordering the disposal of the troops, a disposition seldom approved of by those in charge of stations for timber cutting, sugar estates, &c., who from past occurrences feel the insecurity of their position from the fact that when once the Indians cross the frontier, the Rio Hondo, they have made a successful invasion, and can march by various routes, skirting villages, and halt unperceived in the bush till opportunity offers to make an attack on any station, settlement, or estate; in fact they could pillage and destroy in detail many estates before military aid could be rendered, and an attempt at pursuit would be fruitless and disastrous, unless unusual accident favoured the pursuers. The Indians have a thorough knowledge of the bush tracks, a keen instinct for self-preservation, and from infancy are accustomed to hunt and travel through miles of country with but scanty provisions; being comparatively unincumbered, wearing merely linen cloth trousers and shirt, straw hat, and leather sandals or mocassins, with a gun, powder-horn, and shot-bag or valise, and a machee, they will far outmarch our West India soldiers, who are not in such training, although they cast off much of their cumbersome uniform and accoutrements, and possess considerable powers of endurance, and bear with impunity, apparently, malarious influences that would be highly detrimental to white troops. Their wants are few, they are generally inured to scarcity or irregularity in food, accustomed to prepare it

for themselves, and are expert foragers, even on the line of march if permitted; a few minutes after the halt, fires will be kindled and pots boiling, a pleasant cup of hot tea will be offered, produced from lemon grass and other wild herbs, and a palatable breakfast of simple materials, vegetables, roasted green corn in the ear, &c.; they one and all make excellent soup from their ration meat.

Geographical Position.

Orange Walk is about 40 miles up the New River, southward of Corozal, and N.W. by N. of Belize, about 70 miles by road or track through the bush, and 9 miles east of Albion Island on the Rio Hondo, which river runs approximately parallel to the New River, dividing British Honduras from the Indian territory of Yucatan.

It is a very deep sluggish stream with but three or four principal fords, *i.e.*, convenient places for landing when the river is crossed by dories, or pit-pans, for, like the New River, its banks are fringed for the most part with mangroves or thick bush, almost trackless, and in many parts impenetrable. The Rio Hondo is a strong natural barrier, and our first line of defence can be readily patrolled and watched by a small swift steamer. The key of this position is Albion Island, high land and of good extent, formed by the river diverging into two streams and meeting again.

Block-houses with a few men would guard the other fords, and these detachments might be often relieved and quickly reinforced by means of the small steamer. The depôt for fuel, &c., should be at Corozal, whence reinforcements could be obtained; small detachments (police) might be stationed at Orange Walk, being furnished from Albion Island and relieved by sections weekly, or oftener, thus affording the advantage of patrols to and fro, and keeping up communication between the frontier and the centre of the Northern District, as well as with Belize by the couriers mentioned herein under postal arrangements.

Description of Steam Vessel.

The vessel should have twin screws, so as to turn the quick bends of the river safely. She should have a commodious deck with shot-proof boiler-plate bulwarks, loopholed at certain parts for musketry, also a "dove-cot" (as they were called in the Southern States of America) at the main mast-head (the fore-mast must be clear for canvas) viz., a cylinder of boiler-plate loopholed, from which position sharp-shooters have a good command; the wheel amidships and within a house, with bullet-proof shutters, to be raised in action, having cruciform slits in them, to obtain sights through.

Armament.

Howitzers of large calibre for canister grape and shell, the latter most useful in searching out and dislodging an enemy in the bush; Hale's rockets also are especially serviceable for this purpose.

Site of Barracks at Orange Walk—Selected Site for new Barracks and Block Houses.

Assuming that the garrison is retained at Orange Walk, the present site of the barracks is bad, in a position forbidden to be taken up when occupying a village; they are situated at the re-entering bend of the river, leaving fully three-quarters of the position defenceless, commanded by the adjacent ground and hemmed in by the houses; the bush growing up to and even among many of these houses, sheltered the approach of the Indians, and accounts for the sudden surprise of the garrison; steps have, however, recently been taken for building barracks on a suitable site, defencible themselves, and affording covering protection to the town and settlement; these, with the addition of block-houses on each flank, for the safety of the outposts stationed there, will completely protect the village, for the Indians dread water and never use canoes on the rivers for armed excursions; the local canoes, therefore, dories, or pit-pans being secured, the river forms a secure barrier to the position around which it partially winds.

Precautions on taking up a position in a wild, hostile Country—Check Patrol and its advantages—Precautions to prevent Observation by an Enemy—Check Patrols useful in obtaining Reports and Information.

In taking up or defending a position in a hostile or threatened district, safety mainly depends upon the frequency of patrols and the unobstrusive vigilance of sentries; every patrol should be conducted after the rules laid down for advanced or rear-guards, and additional precaution should be taken to transmit to, and receive communication from, the main body. This would generally be merely an outpost in itself, furnishing an inlying and outlying picquet, with a chain of sentries furnished from the latter, the guard sentries serving as connecting links between them and the outposts. The small number of men available, and the encumbered nature rather than the extent of the ground to be covered, renders the double chain of sentries impracticable for a number of consecutive days; but similar, and almost equal advantage, may be obtained by making the single sentries do their own patrolling between post and post; this is ensured by the following simple expedient of "patrol-checks" (as instituted by Lieutenant Bale, whilst on a tour of out-post duty at Orange Walk, just after the late raid of the 1st September). Say the picquet sentries are out, and the guard sentries (1 and 2) in their ordinary positions; if it is considered desirable to send the check round between reliefs, the Officer on duty or the non-commissioned Officer of the guard takes a "patrol-check" (which may be an oblong piece of wood, lettered P, with a number or letter on it) and accompanied by a file of the guard, goes to any sentry's post he wishes to start it from, say No. 6, and gives it him to carry to No. 5, and 5 to 4, and so on. One of the guard is left to hold No. 6 post, till the "return-patrol" reaches him, this is another check—a bit of wood of different shape, say wedge-shaped, having R P, and a number corresponding to that on the patrol-check, on it—carried by the non-commissioned Officer to No. 1 sentry, who

after receiving the "patrol-check" and ascertaining that all is correct, gives up the "return-patrol;" the latter is then passed back along the chain of sentries, each man resuming his original post, till No. 6 gives it to the guard man at his own post, who takes it back to the guard-room, and the time of its absence is noted by the non-commissioned Officer. This effectually prevents any laxity or irregularity on the different posts, and any observations made by a sentry are communicated for information; the men themselves like the system as varying the monotony; it cheers them to meet a comrade and exchange "all's well" at the other posts, and often trivial scraps of news are God-sends during a period of anxious solitude; it, moreover, keeps the men on the alert without becoming irksome. At night the sentries are instructed to patrol alongside fences and on the grass, avoiding the bare light-coloured ground, and whilst on their posts to stand under the shade of trees or against any dark object, from which they cannot be distinguished at even a few yards distance. The great coat is put on loose over belts and accoutrements, and the sling removed from the rifle, otherwise a white pipeclayed strap will at once reveal the whereabouts of a sentry. The pass or countersign is varied according to instructions from the Officer on duty, and may be a low whistle, two soft taps on the butt of the rifle with the palm of the hand, or any decided but not conspicuously loud challenge. The rounds on duty can at once verify the statement or conjecture of any sentry, as reported to the non-commissioned Officer of the guard, by proceeding direct to the post in question, or if the "check" or "return" is an unusually long time in passing round the chain or *cordon* of sentries, the non-commissioned Officer and a file of the guard patrol to ascertain the cause of delay.

In case of a change in the posts of the sentries being decided on, the non-commissioned Officers of outlying and inlying picquets are assembled and instructed, that they may afterwards explain their orders to the men, and if deemed necessary the men are posted for a short time during daylight, that they may know, and take up their positions without confusion if suddenly ordered out. In case of alarm, the picquet sentries are doubled. After the outlying picquet parades at the guard, or the rendezvous, they proceed direct to their respective posts, and as soon as sufficient time has elapsed, the check is sent round to ascertain if they are at their posts and all correct.

Officers Instructing Men during a Tour of Duty—Cover and Sentries—Shelter from Rain.

It is of great advantage to both the Officer and soldiers if, when the former visits the sentries on their posts he encourages them to give their opinions in addition to answering questions; many valuable suggestions are thus obtained, for no one can know the specialities of a post better than the sentry who has done duty on it a few times; it further encourages the men to make intelligent observation of what is around them, and they feel that the Officers have an interested share in their duties. So with the non-commissioned Officers and men

accompanying an Officer whilst patrolling, admirable opportunities are afforded of illustrating the best way of proceeding unobserved, and acquiring information, if at night or dusk passing along by dark objects and under the shadows of trees, or if the ground is cleared keeping to the hollows, and when stopping to listen, getting beside a tree stem, or down on the grass by a bush. It also tests the vigilance of the sentries, who, if they are Africans, will be faithful to their trust; and if their instructions are to fire if their challenge is not answered, the patrol will be fired into if they do not keep their ears open. A limit of distance for each sentry to patrol on his post is advisable, according to the nature of the cover afforded, and at night they soon learn to conceal themselves effectually. By daylight all advanced sentries should be protected by a temporary cover, concealed by a little growing bush, and be provided with waterproof sheeting, one to lie on and one to cover themselves with in wet weather; all other sentries should have assigned places for shelter, in the event of a heavy downfall of rain, or the percentage of sick from fever and ague would soon make a great deduction from the effective strength of a small outpost force.

Silence and Secrecy Essential—Mounted Men as Patrols—Signalling not Available.

Secrecy in all outpost arrangements is essential, particularly when the natives are disaffected, and may act as spies, and the fewer loud words of command, and especially bugle calls that are heard, the better. The picquet sentries may be recalled during the day by visual signals, passed from post to post, and at night by sending the check round to recall them; they then come in direct from their posts, and no conspicuous signs of movement are apparent.

Cavalry are practically inoperative for the ordinary manœuvres of that arm, but as scouts and patrols, mounted men are invaluable: mounted Zouaves were occasionally employed as such, till His Excellency, Lieutenant Governor Cairns, entrusted the Colonial Secretary, Captain Mitchell R.M.L.I. with the formation of a body of mounted police, to be stationed at Orange Walk; they are commanded by a Sergeant of Constabulary, who speaks Spanish and the Mayor languages; he is a good disciplinarian, and his duty is to receive orders from and report to the local magistrate, who is the Commander of the outpost. Although the force consists of only 12 men, and the Sergeant, they have greatly relieved the burden of Military duties, and established a sense of comparative security, from the regularity with which they bring intelligence from the Fords on the Hondo and the villages, &c., of the frontier. From the generally level and densely wooded nature of the country, semaphore signalling is not available for any considerable distance; the natives signal by firing "Bombas," a charge of powder in any kind of vessel, perhaps a hollow gourd, wrapped or quilted over with cordage or grass fibres, and fired by a slow match, which makes a loud report; these, however, when used by allies to warn the garrison, afforded no intelligence, but caused general and groundless alarm in the neighbourhood.

Indian Drill and Formation of Companies.

Drill adapted to bush work. The Indians have taught us a practical lesson in this respect. Their companies formed in single rank are only twenty-four men, led by a Captain, who has subdivision leaders in the ranks. They usually march in Indian file, one behind the other, through the bush paths, never with a greater front than two abreast, and if they form into line it is only preliminary to a rapid deployment.

Field Exercises and Advantage of adopting Indian Drill—Judicious Tactics of Indians.

In West India regiments, ten men per company are trained and paid as gunners. This number will serve a howitzer. The half companies may be formed as separate companies in single rank, in charge of the guides, and the words of command in present use may serve for precisely similar formations to the Indian drill. This small force then becomes capable of covering a good extent of ground, and is flexible to a degree, but the Captain should be mounted to keep it well in hand; it is capable of counter-manœuvring the Indians by their own tactics, but is backed by a concentrative power unpossessed by them and has the support of artillery fire. The complete surprise of the garrison by the Indians and their orderly retreat after their long but abortive attack, are well known, but since this, particulars of their invasion and march on Orange Walk have transpired, which prove it to have been a well-planned and masterly-executed affair. Their ammunition was neatly manufactured, and the supply of rations of corn cake (unfermented) was sufficient for a week's supply to each man. They secured beforehand a number of pit-pans or dories on the Yucatan side of the Hondo, to effect a simultaneous crossing, and their most advanced files were two miles to the front. They passed all information to the advanced guard as well as persons they met with on their route, who were then transferred as prisoners to the custody of the rear guard, unless they had arms and volunteered to join the main body. This force carefully skirted all villages and plantations, and came unsuspectedly to the rear of the village of Orange Walk, and behind an outlying empty hut, within 100 yards of the magistrate's house. At this place there was all the appearance of an advanced party having bivouacked for some hours during the night. There is no doubt of the supineness or even treachery of the native inhabitants of Orange Walk; and no doubt that the Indians are a subtle and by no means contemptible enemy to deal with.

Earth-work Defences.

The barrack has been protected by earth-works, defended by two pieces of artillery, as far as its defective position will permit, by the Officer commanding the outpost.

Commissariat.

The Commissariat Department is efficient and in harmonious working order.

LECTURE.

Friday, April 18, 1873.

ADMIRAL SIR GEORGE BACK, D.C.L., F.R.S., Vice-President, in the Chair.

THE VOYAGE OF H.M.S. "CHALLENGER."

By WILLIAM B. CARPENTER, Esq., M.D., LL.D., F.R.S., &c., &c.

ABOUT six years ago, my friend, Professor Wyville Thomson, then Professor of Natural History in Queen's College, Belfast, wrote to me that he had received from Professor Sars, of Christiania, intelligence that his son, the Superintendent of Fisheries to the Government of Sweden, had dredged up from a depth of about 300 fathoms, near the Lofoden Islands, an animal of remarkable interest, being a small Crinoid which represented—not the larger crinoids at present known to us as inhabiting West Indian seas, but the fossil form, known to us as the *pear encrinite* of the Bradford clay. You have here a large representation of this creature, the pear encrinite; of the actual size of which you may judge when I tell you that its body is about the size of a small pear. It is a fossil extremely common in the Bradford clay, a member of the great Oolitic formation in Wiltshire. The little specimen dredged up by Mr. Sars is figured here; and you may judge of its size from the fact that I have within this bottle two imperfect specimens which are about the size of large carpet pins, the body being about the size of the head of the pin. On a careful examination of the structure of these specimens, which were afterwards sent over to Professor Wyville Thomson, we quite accorded (having made a special study of this group) in the identification of this specimen as corresponding with this remarkable type, which had been supposed to be long extinct; the only representative of it in any later formation being a Crinoid of the Chalk, which had been only found in one place in the Island of Martinique, and was not known to have existed elsewhere. Here, then, was a fact of very singular interest. In the first place, to find any true Crinoid living on a stalk, attached throughout its whole life, within the seas of Europe, was in itself a novelty of no small account; because up to that time we had known no true stalked crinoid as an European animal. The beautiful *Comatula*, or feather-star, which is an inhabitant of the shores of Great Britain, as well as of many other localities, is a crinoid in its essential

structure; but though a stalked animal in its early period, it drops off the stalk at a certain stage of its development, and from that time lives as a free-swimming form. Here, however, we have, within Europe, a true Crinoid, remaining stalked throughout the whole of its life. But the greatest feature of interest was this: Here, living at a considerable depth in the sea—300 fathoms—was an animal of a type which had been supposed to be long extinct; and its discovery would lead to the surmise that there might be a great many more animals supposed to be extinct, living still in the deeper recesses of the ocean, not having been subjected to those changes of climate, of food, and other conditions which affect to a very much greater degree the animals living near the surface. Then again, supposing this little Crinoid to be the legitimate descendant of that larger one, but to have been dwarfed—perhaps by depression of temperature, perhaps by deficiency of food—supposing it to be, according to the modern view, the actual hereditary descendant of the old pear-encrinite, here was a curious fact, that from that time to this, there had been animals inhabiting the deeper recesses of the ocean, of which no one had known anything, their remains having been neither discovered in the examination of fossilised deposits, nor their living forms met with in any exploration of the existing ocean.

This made us feel that it was a matter of very great scientific importance that such Deep-Sea explorations should be extensively prosecuted; and we agreed that it might be worth while to endeavour to move the Royal Society to make application to the Government, for a vessel which should be fitted for the purposes of deep-sea exploration, the limit to which up to that time had been about 400 fathoms. It had been generally supposed, up to that date, that no life existed at greater depths, excepting those very low types—the minute little *foraminifera*, of which you have here representations; such as the little *globigerinæ*, covering the floor of the Atlantic, which had been brought up by the sounding-lead from great depths. In fact, scarcely any dredging had gone down even to the depth of 300 fathoms. The principal part of the knowledge of the animal life existing even at that depth, had been obtained by a sort of large sounding apparatus; but we considered that any efficient exploration must be done by means of the dredge, and that it was desirable to carry this down to very much greater depths. Of course there were mechanical difficulties in the way; but we thought that these might be overcome, and that, at any rate, it was worth while to attempt to carry down dredging to 600, or 800, and possibly 1,200 fathoms. We made application through the Royal Society, the Council of which readily took up our proposal, to the Government in the year 1868. The Government readily fell in with our views, and assigned to us a vessel of some historical interest—the "Lightning"—one of the first pair of steamers built for the Government service in the year 1825, an old paddle-steamer, which had been latterly employed in the Surveying Service on the Coast of England. We desired to find the deepest water which we could easily reach from the shores of Great Britain; and from the soundings which had been previously taken, we learned that this lay in the channel between the North of Scotland and the Faroe Islands. You see, by

this map, the general situation of this channel, which I venture to call the "Lightning" Channel, because it will be a region of some historical interest hereafter. The white portion of the map is the sea-bottom within the 100-fathom line, lying to the north and north-west of the North of Scotland, and also on the Faroe Banks. Between those two dotted lines in the coloured portion of the map, there is a depth ranging from 100 fathoms down to between 500 and 600, and in some parts even over 600. There is no such deep water as this to be met with so near our shores in any other part.

You are all aware, I suppose, that between Great Britain and the coast of Scandinavia, of Sweden and Norway, and of Denmark and Holland, and again to the south, Belgium and France, there is no water 100 fathoms deep. If the whole of our corner of Europe were raised up not much more than the height of St. Paul's, we should be united almost continuously with the continent of Europe, and Great Britain would be united with Ireland. Of course the Isle of Wight and the Isle of Man would be all taken in, and there would be a considerable extension of the land to the west of Ireland. Here, however, at the north of Scotland it would make very little difference, except that the Orkney and Shetland Islands would be united to the main land. There would still be a deep channel between the north of Scotland and the Faroe Islands. Well, we devoted ourselves, in spite of very bad weather, to the exploration of this channel by means of the dredge; and we also did the best we could in an inquiry, to which it was thought some interest might attach—the temperature of the sea at that depth. Now, at that time the general doctrine was that the temperature of the sea at any considerable depth was uniform all over the globe. That doctrine was partly based on the temperature-soundings taken in Sir James Ross's Antartic Expedition, and partly on other temperature-soundings, which seemed to agree with them. Sir John Herschel had adopted it, and had given it currency, in his very valuable Treatise on Physical Geography; and in this country the authority of Sir John Herschel gave that statement such weight, that no one thought of questioning it. Still it was thought that some good might accrue from making careful observations; and we went out provided with the best thermometers we could obtain. We very soon found remarkable and unexpected results; and to these I will first direct your attention. We found, in some of our soundings, at a depth of 500 or more fathoms, a bottom temperature of 33°. In other instances, we found on the very same bottom, at the very same depth, and perhaps within 20 miles, a temperature of 45°. Now, what was the meaning of this? It occurred to me that it must mean that there are two currents; one from the north-east, bringing down a polar temperature; and one from the south-west, bringing up a temperature warmer than the normal of the latitude,—for as that latitude was 60°, the normal temperature of that latitude would be below 39° at the surface, still more therefore at any considerable depth. We carried out this investigation much more fully the next year; and we were then provided with thermometers that could be relied upon. For having been led to suspect that even the very best thermometers—the

thermometers of the Admiralty pattern, manufactured by Mr. Casella—were not to be trusted at pressures even so moderate as these (for we are accustomed now to consider 500 fathoms as quite shallow water), we caused experiments to be carried on by Mr. Casella, by placing these thermometers in a hydrostatic press, and subjecting them—not to the pressure between two boards, such as goods are pressed between in packing—but the pressure of water, which would press equally all round. They were put, in fact, into the interior of the hydrostatic press, and subjected to a pressure ranging up to three tons on a square inch. The pressure of a column of water of 800 fathoms depth is just about one ton on the square inch; so that the pressure of 2,400 fathoms (and we have passed that depth in our temperature soundings) is equal to three tons on the square inch, the utmost pressure the hydrostatic press would afford. It was found that the very best of the Admiralty thermometers under this pressure went up 8° or 10°; and that thermometers of other makers, not so well constructed, went up 20°, 30°, 40° or 50°. So that you see it was at once shown that all the old observations taken at any considerable depths were utterly untrustworthy, and that the only use we could make of observations taken with them was by correcting them for the *minimum* of error. For example, if Sir James Ross obtained 39° at a depth of (we will say) 2,000 fathoms, we should be quite sure that his thermometers were wrong at least 7° or 8° at that depth; and that the real temperature which the thermometers ought to have indicated, was about 31° or 32°. Our own first year's observations were not invalidated to anything like that degree, because they had not been taken at any depth greater than 530 fathoms, except 650 in one instance; and, at any rate, I felt sure on returning from that first expedition, that the observations made with the ordinary thermometers were good to this extent—that they correctly showed the *difference* of submarine climates; because here, on the very same bottom, and within 20 miles of one another, were temperatures so different as 33° and 45°; so that, whether the real temperatures were or were not lower, the difference between them would still be the same. The late Professor William Allen Miller devised a means of protecting the bulb of the thermometer, which simply consists in enclosing it in an outer bulb that acts as a sort of buffer, and takes off from the inner bulb the pressure on the outer; the space between the two being about three-fourths filled with spirit. These protected thermometers are all subjected to the severest test in the hydrostatic press; and the pressure of even three tons to the square inch has scarcely any influence in sending up the liquid. They may be regarded as registering, in the most trustworthy manner, within a degree; and where two thermometers are employed together, I believe we may rest with the most complete assurance on that agreement.

We found, then, on taking *serial* soundings—that is, sending down the thermometer repeatedly at gradational depths, or sending down several thermometers attached to the sounding line at different points, so as to be able to take the temperature at 50, 100, 150 fathoms, and so on, so as to be able to obtain the temperature of different strata at

the same time in the same spot—that there was distinct evidence in "the cold area" of two strata of water, an upper stratum of water warmer than the normal of the latitude, and an under stratum of water very much colder; and thus my previous suspicion of the existence of a double current was completely confirmed. You will see that the surface temperature is the same in both these sections, that the temperature goes down in the first 100 fathoms very nearly at the same rate in both; but below 150 fathoms the temperature very rapidly decreases in one, while it changes but little in the other. Every line in that diagram represents one degree of temperature; and you see how the lines are crowded together between 200 and 300 fathoms, that being the depth at which the great change takes place in what I call the "stratum of intermixture" between the one and the other. Below 300 fathoms we come into a stratum of water more than icy cold; for with these improved thermometers we could register the temperature exactly, and that temperature we found to go down to 29½°. You will ask me why the water did not freeze at that temperature. Salt water does not freeze at the same temperature that fresh water does; and salt water contracts continuously to its freezing point, so that it becomes heavier as it becomes colder. That is a very important fact, which (as you will immediately see) has an essential bearing on the general doctrine of oceanic circulation. Fresh water, as I presume you all know, ceases to contract in cooling when it reaches 39°, and it then begins to expand again, so that at 32° the water is as bulky (and therefore as light) as water at 46° or 47°. But sea water continues to contract down to its freezing point at 27° or 28°, or even 25° if kept very still, becoming less and less in bulk down to that degree, so that it is at its least bulk and greatest density just before it freezes. That is a point to which I shall have presently to return.

We found then that the Animal Life of these two areas differed just as much as the Temperature; and I will now direct your attention to a few of the forms of interest which we obtained in our first expedition on that area.

This very beautiful Siliceous Sponge was one of our most fortunate captures. It came up just on the borders of the warm area, in the midst of the mud, partly mixed with sand—the globigerina mud, of which you have a specimen in this bottle, which exactly corresponds with this that was obtained from three miles' depth in the Atlantic—a substance corresponding in all essential particulars with Chalk. The great interest attaching to this siliceous sponge was, in the first place, its being an entirely new type of a group to which attention has been of late very considerably directed: the group of siliceous sponges, with one form of which you are all, I doubt not, familiar, the very beautiful *Euplectella*, or Venus's flower-basket. The special interest of our *Holtenia* to geologists, is that it very closely represents the Ventriculites, a large group of fossils extremely abundant in our Chalk. I happened to be speaking of this in going over Lewes Downs at the time of the meeting of the British Association at Brighton, and a gentleman present said, "Oh, yes, when I was a boy I used to collect "ventriculites in the chalk pit of this very hill in any quantity." It

was peculiarly interesting to find a representative type of this class of fossils of the old chalk, in this new chalk now in process of formation; and I think I may say that it was the discovery of this specimen which procured for us all the facilities subsequently afforded us for the prosecution of our researches, and that it has really been the foundation of the "Challenger" expedition; for the interest which it excited amongst naturalists and paleontologists was such as at once to make the Council of the Royal Society feel that the inquiry ought to be thoroughly carried out.

We met with a great many other specimens of great interest, and amongst them these little-*Rhizocrini*, corresponding with Professor Sars's Crinoid, at points remote from each other, showing that they must be very extensively diffused.

We were able in our second Expedition—that of the "Porcupine," commanded by Staff Captain Calver—to carry down our dredging to the depth of 2,435 fathoms, and that dredging brought up 1½ cwt. of Atlantic mud, with a large number of animals of different kinds, representing all the great groups of marine animal life, and amongst others, these two specimens of the little Rhizocrinus. They unfortunately want their arms, which, I suspect, were carried off in the trailing along the ground during the operation of dredging. There came up also a great number of extremely curious forms of Foraminifera, which constitute so large a proportion of the animal life of the sea bed, that I think I may say without hesitation, that this mass of Foraminiferal life, chiefly composed of Globigerinæ, at present covering the floor of the Atlantic, far surpasses the whole Terrestrial life of the present time. The floor of the North Atlantic over every part which has been sounded, excepting in some few places where the Arctic drift seems to be brought down by special under-currents, is covered entirely with this globigerina mud to a depth of which I have no knowledge whatever. I can only say that in one place we brought up half a ton of it from a depth of 700 fathoms; and at the great depth I previously mentioned, 2,400 fathoms, the dredge brought up 1½ cwt. The surface of this is alive, and all that lies below the surface is the remaining product of animal life.

Time will only permit me to give you a summary of the general condition of things which we found in the bed of the deep sea. We brought up a very considerable number of animals representing forms which formerly existed, but were believed to be extinct. Among the large number of shells dredged up in the immediate neighbourhood of Great Britain, the number new to the British Fauna was more than one-fourth of the whole number previously known as British, and a great many of them new to science altogether, requiring many new genera and a great number of new species to be created. The greatest interest, however, was in the number supposed to be extinct, but found to be still living at the bottom of the sea. Then we found a great number of types of star-fish and sea-eggs of various kinds, belonging to the Cretaceous formation; some of them most curiously bringing down to the present time the plans of structure typical of the Echinoderms of the chalk. We found the distribution of animal life pre-

senting a very marked difference, according to the Temperature, on bottoms within a few miles of each other. The animals of the cold area were for the most part quite distinct from those of the warm area; though some were found everywhere. These sea-eggs (*cidaris*), which belong to a species previously rare, we found anywhere and at any depth or temperature. We found the same in the Mediterranean, between 100 and 200 fathoms, as we had found at considerable depths in the North. Here again are very curious crustaceans,—slender-legged creatures, like spiders, with scarcely any body—all legs—some of them extending six or eight inches across; these we found both in cold and in warm areas. But, as a general rule, the shells and Echinoderms and Foraminifera and Sponges were very different. I could not detect a single globigerina in the cold area, as they seemed to be entirely limited by the temperature. On the other hand, in the cold area we had a large and most beautiful Sponge, of quite a new type, which seemed to cover the cold area everywhere; and, I believe, furnishes food to the higher animals living in the cold area, very much as the globigerinæ furnish food to animals living in the warm area. We ourselves may really be said to feed on globigerinæ. I will tell you the sequence. We feed on cod. Supposing cod are brought, for example, from the Faroe Banks; these cod feed upon a kind of star fish, for the star fish are found in the stomachs of the cod; and then when we examine the stomachs of the star fish, we find that they feed upon globigerinæ; so that, to the extent to which we depend upon cod for our food, we may be said to depend upon these globigerinæ. I might follow the same line of inquiry a little further. What do the globigerinæ feed on? and there we are stopped by a very great difficulty. The solution of this problem I believe to have been afforded by the suggestion of Professor Wyville Thomson, that the globigerinæ really absorb liquid protoplasm diffused throughout the entire mass of sea-water—the sea-water being in fact a very dilute protoplasm, or very watery soup. This we find fully confirmed by the analyses that Professor Frankland was kind enough to make, of the samples of water which we brought him;—investigations of which, I have no doubt, will be carried on with samples supplied from every part of the great ocean-basins of the globe.

I must not say anything more with regard to the animal life, except in pointing your attention to these curious specimens. Here are some small star fish, not more than two inches across, which we dredged up in the cold area. They are the common "five-fingers" of our own coast, which range to the diameter of a dinner-plate. Our ordinary large 12-rayed star fish, which I have seen certainly 8 inches across, are represented in the cold area by these specimens not larger than a crown piece, which are clearly dwarfed by the low temperature. It is a matter of peculiar interest to see how such low temperatures affect forms with which we are perfectly familiar; because then we get the clue to the same influence operating through very long periods of time in reducing such a form as the Pear-encrinite to such a form as this little Rhizocrinus. This now lives in a cold bottom; but it is probable that the bottom on which it originally lived was much warmer.

Temperature and abundance of food would both have a very important influence; and the reduction of both would, in the progress of ages, be an adequate *vera causa* for the reduction of the older form to the present type. I may mention, that in a later cruize we obtained an extremely interesting example of a type of crinoids, which we knew to be still existing—the West Indian *Pentacrinus*. We brought up 20 specimens of it off the coast of Portugal, from a depth of between 800 and 900 fathoms. This is a very interesting fact, because it is a type of crinoids of which you will see abundance in the lias of Lyme Regis and elsewhere; and its presence has been supposed to indicate a warm temperature and a shallow bottom. But we found this living at a temperature of about 48°, and on a bottom of between 800 and 900 fathoms. These researches, therefore, tend very greatly to correct geological theory; by supplying a large body of new facts, which very often to a certain degree disturb our existing notions, but which also give us an entirely new and more secure basis for the construction of our doctrines.

Now, let me return to one of the great objects of interest connected with these explorations, the movement of water as indicated by its temperature. We have, as it were, a sort of epitome of that which I believe to be going on in the great ocean-basins, presented to us in the region we have examined. In taking temperature-soundings on the Atlantic Coast, from the Faroe Islands as far south as the Strait of Gibraltar, we found evidence of a very low temperature in the Atlantic, below about 1,000 fathoms. At about 1,000 fathoms we meet with 39°; then going still deeper, with 38°, 37°, and 36½°, at 2,435 fathoms. Off the Coast of Lisbon we found just the same "stratum of intermixture," between 800 and 1,000 fathoms, that we got in the cold area between 200 and 300 fathoms; for there was a sudden change from 49° to 40°, a reduction of 9° of temperature in about 200 fathoms. That seems to me a very significant fact, and particularly so when we take into account the contrast between the temperature of the Atlantic basin and the temperature of the Mediterranean inside the Straits of Gibraltar. The deeper part of the Mediterranean basin, which goes down to 2,000 fathoms between Malta and Crete, may be said to be completely separated from the Atlantic basin; for there is a ridge across the western *embouchure* of the Strait, of which a large part is within 100 fathoms, while its deepest part is 200 fathoms; so that this great Mediterranean basin is entirely cut off, as regards all below 200 fathoms, from the great basin of the Atlantic. That being so, what do we find? In the Mediterranean, from 200 fathoms to the bottom, at any depth, *the temperature is uniform*. The surface-stratum is superheated in the summer to 80°; and at 100 fathoms that superheating influence is almost entirely lost, so that the thermometer goes down to 56° or 54°; and whatever it is at 100 fathoms, that it is down to the very bottom. On the other hand, in the outside Atlantic, you will see somewhat the same superheating effect down to 100 fathoms, the thermometers falling from 68 to 53; then a very slow descent; but then at 800 fathoms a sudden fall, and the whole below 1,000 fathoms we know to be below 40°, going down to about 36°. I am able to show you the first fruit of the

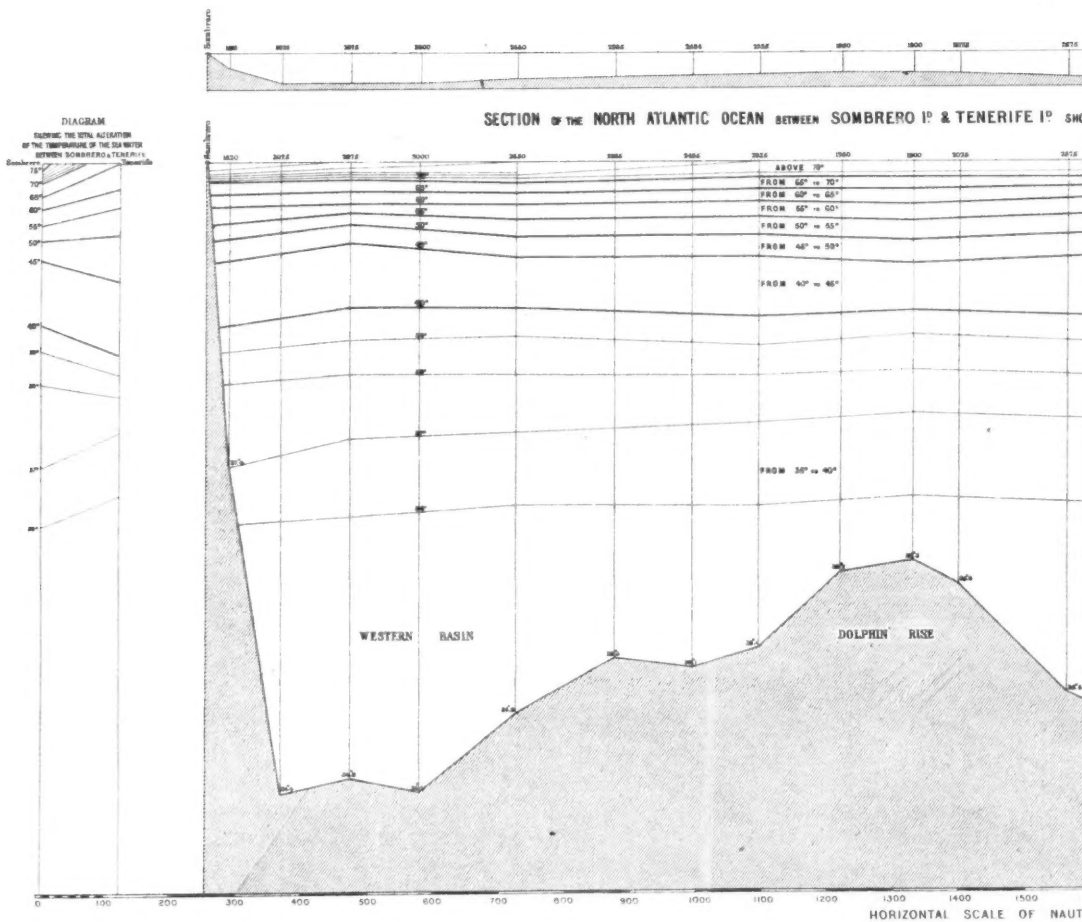


DIAGRAM
SHEWING THE TOTAL ALTERATION OF THE TEMPERATURE OF THE SEA WATER BETWEEN SOMBRERO & TENERIFE
Sombrero
Tenerife
SECTION OF THE NORTH ATLANTIC OCEAN BETWEEN SOMBRERO Iº & TENERIFE Iº SHO
ABOVE 70°
FROM 65° to 70°
FROM 60° to 65°
FROM 55° to 60°
FROM 50° to 55°
FROM 45° to 50°
FROM 40° to 45°
FROM 35° to 40°
WESTERN BASIN
DOLPHIN RISE
0
100
200
300
400
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1000
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1200
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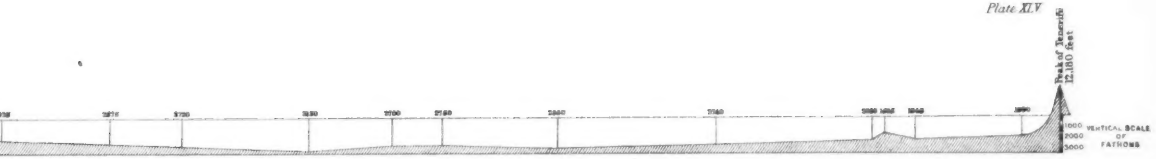
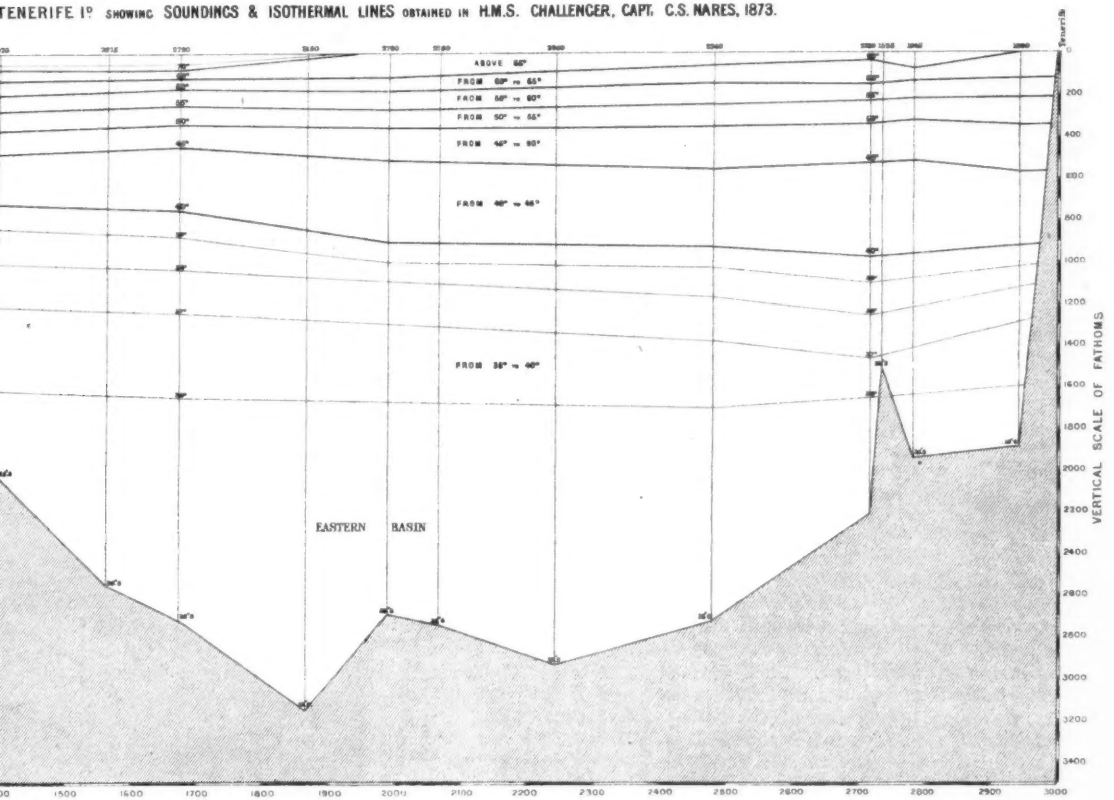
1400
1500
HORIZONTAL SCALE OF NAUT

Plate XLV



TENERIFE I° SHOWING SOUNDINGS & ISOTHERMAL LINES OBTAINED IN H.M.S. CHALLENGER, CAPT. C.S. NARES, 1873.



SCALE OF NAUTICAL MILES.

exploration of the "Challenger," kindly lent me by Admiral Richards.* This is a Temperature-section taken across the Atlantic, from the Peak of Teneriffe to St. Thomas's. You will see here the different strata distinguished by lines of equal temperature; in the upper part at intervals of 5°, in the lower part at intervals of 1°. It is at a depth of about 900 fathoms, exactly as my own soundings had led me to believe, that this line of 40° is to be found; and every one of these lines below indicates a degree of temperature; the whole mass of water below 1,600 fathoms does not exceed 36°, and the thermometer goes down at certain points to 34°; so that you will see that these cold bands of temperature which have been occasionally encountered by former explorers, were not mere little local currents, but —as I ventured to predict would prove to be the case—indicated the temperature of the whole mass of water in the Atlantic. On the western side of the Atlantic it is about a degree lower than it is upon the eastern side; and I rather suspect that this has reference to the cold Arctic current which comes down from Greenland and Labrador, along the eastern seaboard of the United States. The greatest depth which has been obtained is, I think, 3,100 fathoms; but it had not the lowest temperature. Its temperature was 35½°.

The view of Ocean-circulation which I have been led to promulgate, on the basis of the facts which we obtained, is one which is not new. Though I was not aware of it at the time I put it forward, it had been promulgated by the great French physicist, Pouillet, more than 30 years ago; but it was subsequently put aside for the doctrine which had been espoused by Herschel. Pouillet said, "The facts at present "known to us lead to the surmise that on the one hand there is a con- "tinual movement of water from the Polar areas towards the Equator, "at the bottom of the sea; and, on the other hand, a continual move- "ment of the surface-water from the Equatorial area towards the Polar "areas." He did not give any precise indication of the forces which would keep up this movement; but any physicist will readily understand that there would be likely to be such a movement, when once the fact is taken into account that sea water continues to contract as it is cooled down to its freezing point, and does not expand again, as fresh water does. It was in working out that simple principle, that I was led to what appears to me a very definite notion on the subject, which is simply this:—Supposing you have a long trough (and this I exhibited experimentally three years ago at the Royal Institution, and two years ago at the Geographical Society) with glass sides, filled with water; at one end we wedge in between the glass sides a lump of ice; at the other end we carry heat from a spirit lamp, by means of a metallic plate, not to the bottom, but to the surface of the water. That would represent the condition of things in the Polar and Equatorial areas; in the Polar area, the continual action of atmospheric cold; in the equatorial area, the action of solar heat upon the surface. We found, by putting in some colouring liquid, that a continuous circulation was set up; the water

* The sectional diagram of depths and temperatures here given, is from one of a series being prepared by the Hydrographic Department of the Admiralty, and is inserted by permission of Admiral Richards, the Hydrographer.—ED.

was drawn towards the Polar end, and, when it came into contact with the piece of ice, tumbled down as it were to the bottom, then slowly crept along the bottom to the opposite end, and there rose gradually to the surface under the heated plate of metal, and was then drawn on again towards the Polar area. So long as any ice continued at one end, and the heating action of the lamp continued at the other, so long the circulation continued, the one influence antagonising the other. The sudden and complete fall to the bottom of the water which came in contact with the ice, is simply the result of the increase of its density by the reduction of its temperature. Supposing there were two columns of the same height but of different densities, the column of greater density, that is the colder column, has a greater pressure not merely downwards, but laterally; therefore it flows out laterally, and as it flows out, it lowers the level, and more water is drawn in to replace it. Then as surface-water is drawn from the Equatorial area to the Pole, the bottom-water of the equatorial area will be continually rising upwards, being pushed up by the colder water which comes in below it; and in this manner there is maintained (I venture to affirm) a constant oceanic circulation, by a force just the converse of that which produces the circulation in our hothouses. In our hothouses and public buildings, we heat water; that water becomes light, ascends, goes through the pipes, becomes chilled, and comes in at the bottom of the boiler, being then heavier, and as long, therefore, as there is heat applied to the bottom of the boiler, and cold applied to the pipes in the building, so as to cool the water previously heated, keeping up the difference of temperature between boiler and pipes, so long there will be a continual movement. In the case of the oceanic circulation, the prime moving force is not heat at the bottom, but cold at the top. Heat sends the water up, because it is lighter; the cold at the top sends it down, the water is heavier. This is perfectly easy to conceive, and I can only say I am exceedingly surprised at the opposition this doctrine has met with. It was entirely accepted by Sir John Herschel, in a letter to myself, only a month before his death; it has been entirely accepted by Sir William Thomson, the greatest living authority in this country upon all subjects connected with the theory of Heat; and it is entirely accepted also by the President of the Royal Society. I therefore venture to put it before you with some confidence.

Now the working-out of this theory is one of the great objects of the work of the "Challenger." It was a point specially put before the First Lord of the Admiralty, when the first representations were made to him on the subject of a Scientific Circumnavigation Expedition, that there should be a careful temperature-exploration made of the great Oceanic basins. In the first place, the "Challenger" has gone across to Teneriffe, and she then goes to St. Thomas's. She returns from St. Thomas's in the line of the Gulf Stream towards New York, touching at Bermuda; then she comes back again to the Azores; and thus will take two sections across the Atlantic, one about 20° further north than the other. We hope that it may be possible to obtain in the neighbourhood of the Azores mechanical evidence of the under-movement of the deep stratum. I do not think that it should be called a "current." I

never believed it was anything more than a "creeping flow" (just like that which I was able to exhibit in the experiment), of, it might be, 6 or 8 miles a-day. And there is very curious evidence that there is such a flow. The first Atlantic cable of 1865 was buoyed with a long wire rope in about 1,900 fathoms deep, and to that rope was attached a buoy floating at the surface. It was hoped, when the "Great Eastern" went out the next year, that the buoy might still be found attached to the cable, and that the cable might be picked up by its means. That hope was disappointed; the buoy was not found, it had got adrift; but it was afterwards ascertained that the buoy had been seen by one of our West India mail steam ships, at a distance considerably to the south-west of the point at which it had got adrift. Now it was in the line of the Gulf Stream; how, therefore, could it drift to the south-west? The drift must have been from 6 to 8 miles a-day, supposing it had got adrift very soon after it was attached. The only explanation I can see would be, that this great under-stratum (beneath the line of 40°, perhaps beneath 43° or even 45°) is a mass of water slowly moving from the Pole towards the Equator. You will see, therefore, that a cord hanging down in this deep stratum would present a much larger resisting surface than the upper part of the cord and the buoy itself. Therefore supposing that there are two movements of water in the opposite direction, the much greater hold will be upon the lower part, and that would be an adequate cause for the drifting of the buoy south-west. The "Challenger" has lately obtained evidence in certain parts of the Atlantic, which seems to justify the belief that there is such a movement, though they have not obtained direct mechanical proof. They find that, instead of the bottom being uniformly covered with this Atlantic ooze, there are parts where it is rocky, and where the dredge is fouled; and from a letter which I saw a few days ago, I gather that Captain Nares is of opinion that there must be a movement of water over the bottom; that it has not that stillness which has been usually assigned to it; but that the water must be in a state of flow so as to keep some of the prominent parts bare. I do not know on what part this observation was made, but it may have been about this rise (pointing to the diagram), which seems to separate the area of the Atlantic between the Azores and America into two basins.

In the instructions given for the "Challenger's" work, I threw out a suggestion that the experiments for the mechanical determination of this current in the neighbourhood of the Azores might be effectual; that mechanical determination being made in this manner. I was engaged with Captain Nares, and previously with Captain Calver, in the investigation of the under-current of the Strait of Gibraltar, and we used there a "current drag." It has two pairs of large vertical wings, fixed at right angles to each other, so as always to present an expanded vertical surface to the water, and to be caught by any current that may lay hold of it when floating it from a buoy on the surface. By making due allowance for the strain of any surface-current upon the buoy, which is a matter of very great importance in working out observations of this kind, we found that there was not much difficulty in determining the existence of an under-current in those straits at a

depth of from 200 to 300 or 400 fathoms; but it has yet to be seen whether it will be possible to work such a current-drag at a depth of 1,000 or 1,200 fathoms. Captain Nares, I believe, is very sanguine of success in doing so. This current-drag was worked with very complete success by the "Shearwater" last autumn in the Straits of Dardanelles; and Captain Wharton there proved the correctness of the prediction I had ventured to make, upon theoretical grounds, that in the Straits of Dardanelles there would be found an under-current going inwards beneath the surface-current which runs outwards, in consequence of the difference of density—produced not by difference of temperature, but by difference of salinity—the specific gravity of Black Sea water being kept down to much less than that of the Ægean or the Mediterranean, by the excess of fresh water that flows into it above the evaporation. There is a similar inward under-current in the Baltic Sound, carrying back salt into the Baltic Sea, as in this case into the Black Sea. On the other hand, in the Strait of Gibraltar, the under-current is outwards, the surface-current being inwards, the conditions being exactly the converse; for the water of the Mediterranean is heavier than that of the Atlantic, the evaporation being greater in amount than the fresh water it receives. The consequence is, that the column of Mediterranean water is heavier than the column of the Atlantic water, and therefore presses outwards. In the Dardanelles, and in the Baltic Sound, the outside water is the heavier, and presses inwards.

Now I will take up the route of the "Challenger" to show the objects contemplated in her work. She will, I hope, be able, on returning to the Azores, to make the mechanical experiments which I have suggested; as I believe it to be there, coming down between Iceland and Greenland, that the greatest stream of cold water is to be met with —the cold water that reduces the temperature of the great basin of the North Atlantic. You must not suppose from the look of an ordinary chart, that the channels of communication between the Arctic basin and the North Atlantic are nearly as wide as they seem. You know that in a Mercator's chart all these northern distances are very greatly exaggerated; and the passage between Iceland and Greenland is really a narrow one. Between Iceland and the Faroe Islands, there is no deep water at all; for there is a bank of about 200 fathoms, which keeps all the cold water back. Between the Faroe Islands and the north of Scotland, there is a channel of 500 or 600 fathoms; and there, as I have shown you, there is a cold stream, great in itself, but nothing in comparison with the enormous area of the North Atlantic. I believe we shall find that, putting aside the North Pacific, the North Atlantic has the highest bottom temperature of the great oceans; for cold as it is, coming down in one place to $34\frac{1}{2}°$, I believe we shall find all the southern oceans colder still. The "Challenger" will then go on dredging and sounding all the way from the Azores, pretty nearly due south, keeping midway between the two great continents, and traversing the deepest part of the ocean as far as the equator; and she will then, after approaching the coast of Africa, cross towards South America, taking another section of the Atlantic just under the equator. This will be very important for comparison of the temperatures taken

under the equator, with the temperatures taken along the two northern sections. I have every reason to believe that under the equator we shall find it colder than it is found farther north; for between Sumatra and Ceylon, Commander Chimmo has met with a temperature of 32° at a depth of 2,500 fathoms, within five degrees of the equator. I believe the same will be found here, and why? Because you see there is an uninterrupted access of Polar water all the way from the South Pole. Whilst the North Atlantic basin receives only some tributaries of Arctic water, there is a great, broad, uninterrupted flow from the whole Antarctic area into the great southern oceans.

Having touched at Brazil and Rio Janeiro, the "Challenger" will then go across to the Cape of Good Hope, taking another section across the South Atlantic. Having passed the Cape, they will run to Kerguelen's Land, in the summer of the southern hemisphere—that is, next January. They will thence take a section, by going due south, or as nearly due south as may be, towards the great ice barrier; running as close to it in fine summer weather as may be considered expedient, and thereby taking a series of temperature sections, which will show us, not as here, the bands running nearly straight across, but what I believe will be an inclined plane. The temperature of 40° will then be found at the surface; and all the lower temperatures will come much nearer the surface than they do in this cross section. That examination of the temperature is one great object of this part of the expedition; and at the same time, the exploration of the animal life of these southern areas, as to which nothing whatever has been done, beyond one or two little scrapes at 400 fathoms taken by Sir James Ross, and a few specimens obtained by the sounding line. Returning thence, the "Challenger" will proceed to Sydney, and will, I suppose, remain there some little time for repairs, refitting, and rest. Then on starting from Sydney again, she will cross to New Zealand, and take a southern turn there; for there are a great many matters of very great zoological interest which it will be desirable carefully to examine. A good deal is known of the marine fauna of New Zealand, and what is known, leads us to the belief that there will be much to repay further research. In the Indian Archipelago, to which the "Challenger" will afterwards proceed, the ups and downs of the bottom are very extraordinary. By the kindness of Admiral Richards, I have had particulars of the temperature-soundings sent home by Commander Chimmo; and it is curious to see the enormous depths sometimes met with in the neighbourhood of land. For instance, in the Celebes Sea, one of the deepest soundings was obtained that had ever been taken, about 2,800 fathoms. And I may mention that in all these soundings the temperatures correspond exactly with what we should expect when we consider what access the Polar water has to the particular locality. For example, here, as I mentioned, between Sumatra and Ceylon there is free access of Polar water; and the bottom temperature is reduced to 32°. In the Celebes Sea, that access is made circuitous by the land; but still the thermometer goes down to 38°. In the Zulu Sea, the temperature resembles that of the Mediterranean; for it goes

down rapidly at the surface and then stops at 50°, and down to 1,600 or 1,700 fathoms it is still 50°. The reason of this is to be found in the fact, that this little sea, though not enclosed on the surface more than very partially, is shut in below by continuous reefs, forming a sort of crater or cup; and within that crater the temperature is constant, just as it is in the Mediterranean. There is probably no more interesting region in the world for zoological and for temperature exploration, than this Eastern Archipelago; and we anticipate from it the richest harvest of results of both kinds.

The "Challenger" will go round the Phillippine Islands, New Guinea, the Solomon Islands, and will then pass northwards along the line of the warm current, which there takes the place of the Gulf Stream current in the Atlantic. This warm current is simply the result of the equatorial Pacific current driving onwards until it meets the land, and then turned by it to the north, just as the Atlantic equatorial is turned by it to the north-east. From Japan, the "Challenger" will go across the Pacific to Vancouver's Island, taking temperature soundings and dredgings the whole way. This is an entirely unexplored bottom. I said just now that I ventured to predict that the bottom temperature in the North Pacific would be found higher than that of any other ocean, and why? Because it has no communication whatever, as regards deep cold water, with the north Polar basin. You all know, of course, that the only communication of the North Pacific with the Polar basin is by Behring's Straits, which is not only a narrow but a shallow channel, having no more than 20 fathoms of water. Through that shallow channel no cold water can come down, and therefore Behring's Straits is practically a coast line to the cold water of the Polar Basin. Any cooling of the bottom of the North Pacific, therefore, will depend upon water that comes all the way from the South Pole; just as the cooling of this area between Aden and Bombay to 35° or 36° depends on water that has crossed the Equator. I quite expect to find that the temperature of the Pacific, even as far north as Columbia, may be reduced to 36° or thereabouts; but I do not think it can be colder than the North Atlantic, and I should expect to find it a degree or two warmer, in consequence of having no communication with the Arctic basin. (I believe that the cooling of this great mass of water in the North Atlantic must be due fully as much to water that has come from the South Atlantic as to the North Polar water, so small are the streams that can come even from the North Polar basin.)

The "Challenger" will then stretch out into the deep portion of the Pacific, keeping at a considerable distance from the coast till it is necessary to put in for supplies; and carrying on the same series of explorations in the eastern portion of the Pacific, as previously on the other side. We suggested that she should run out rather further, if time allows, into the middle of the Pacific, taking a longer loop than is here laid down. Then the same series of inquiries will be carried on round Cape Horn and on the eastern side of South America.

This is a general sketch of the work which she has to do; the purpose being, in the first place, the thorough and complete Physical examination of the Ocean as regards depth, the temperature at all depths, in

all strata, the surface temperature, the currents, the movements of the surface by wind and other causes, the deep movement, the composition of the water in different parts, the specific gravity, the proportion of saline constituents, and especially of the gases, which have a most important influence on the distribution of animal life, and the question of the universal presence of organic matter, which is one of the most interesting points of all. Dr. Frankland was quite astonished at the amount of this in the samples of water which we brought home, taken at some 200 or 300 miles' distance from land, and at a depth of several hundred fathoms. The question will be to find whether the presence of organic matter is equally conspicuous in water from the great oceanic basins, as it was in our small corner. Then, of course, the examination of the Animal Life from all depths and in all parts where it may be found feasible to carry on these explorations, will be a leading object. There are certain bottoms, near land especially, which are very rocky, and where it is very difficult to work the dredge with success; and there, probably, it may not be possible to obtain all that would be desired. But still we have means, even there, of getting samples of great value; and I may just mention that one of the most important additions we made to our dredging apparatus was a sweeping apparatus, the bottom being not only scraped by the dredge, but swept by hempen tangles like swabs. (It does not answer, however, to employ *used* swabs; we had to make them for the purpose, because it is only when freshly made, the adhesiveness of the fibre still remaining, that the swabs are effective.) These tangles were most wonderfully effective, not so much for bringing up shells, as for bringing up echinoderms and all kinds of crustaceans, corals, &c., that they laid hold of. I may give you, as an example of their extraordinary effectiveness, this circumstance, that in dredging near the Shetland Islands, our tangles came up loaded with one species of sea-egg, about the size of the top of my finger. This species had been previously known by ones and twos. There were, perhaps, half-a-dozen specimens of it in museums, not more. Our tangles came up, on a moderate estimate, loaded with 50,000 of them. Here are some that were cut off and put into this bottle exactly as they were laid hold of by the hempen tangles. I suppose there are fifty specimens in this bottle, and these were nothing to the mass we brought up. Again, our tangles came up over the cold area, laden with this beautiful comatula, which we had previously only known through specimens costing five guineas a-piece, brought from Iceland and Greenland.

I have thus endeavoured, as fully as our limited time will allow, to place before you a general idea of what the work of the "Challenger" is. It is to carry out in these great ocean basins the kind of exploration which we had found effective in the short investigations which we had had the opportunity of engaging in; thanks to the constant assistance of the Government, and particularly I must say to the unwearied kindness of Admiral Richards, who was always ready to promote our views; and thanks, I must also say, to the liberality of the Chancellor of the Exchequer, who, from the very first, took a very great interest in this inquiry, and to whom I went, before moving the Admiralty on the

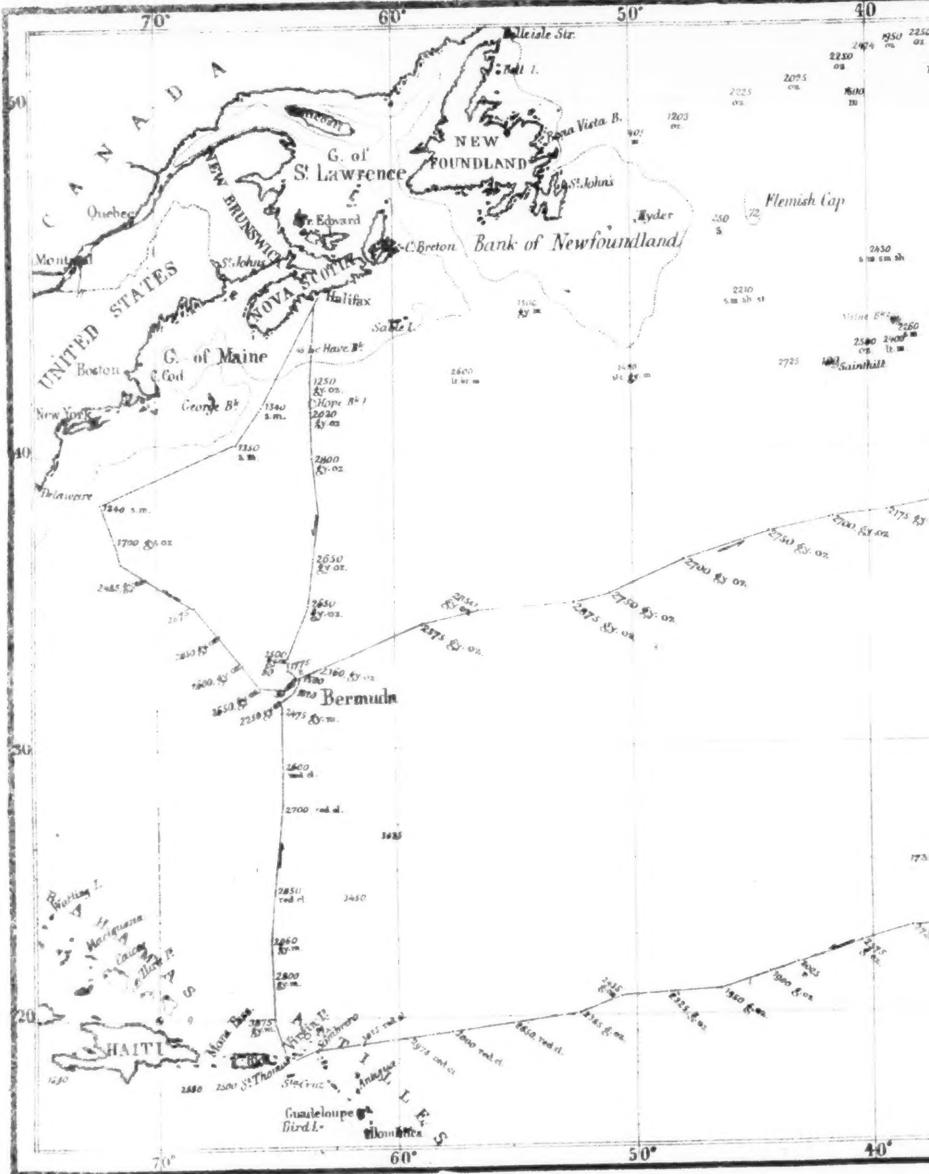
subject of the "Challenger." I first secured the cordial concurrence of the Chancellor of the Exchequer, who told me that anything the Admiralty considered to be proper in this matter, would meet with his entire support. I have felt it right on all occasions to state this, because I believe the principle on which the Chancellor of the Exchequer proceeds in these matters is the right one. I do not say it may be always rightly applied, but I believe the principle is right, that what private enterprise can well do, private enterprise should be left to do; but what only a Government can do for the promotion of science, by its organization, by its means and appliances of various kinds, the State should do. On that principle Mr. Lowe has acted consistently, with regard to the three successive applications which we made for carrying on our previous work, with regard to two Eclipse expeditions, and with regard to this, the greatest of all, the "Challenger" expedition. With respect to any further propositions for Arctic research, or the like, it is not that he considers they are wrong in principle, but it is simply a question of policy as to whether it should be carried out. It is due to Government to make these statements, because nothing could have been more liberal and effective in every way than the fitting out of the "Challenger" expedition. Everything the Royal Society could ask for has been liberally done, and I venture to hope that the results of this research will be such as to present what will be universally felt to be an adequate return for the expenditure of mental power and of money involved in its preparation and execution.

The CHAIRMAN: It is impossible for any one to have listened to this most interesting lecture of Dr. Carpenter's without perceiving the amount of scientific knowledge and of rare analysis which he has brought to bear upon it. His elaborate report to the Royal Society last year on the scientific researches of the vessels just mentioned, and more especially his own vast labours, must be studied to be appreciated as they deserve. And now that he has had the goodness to foreshadow what may be reasonably expected from the work of Professor Thomson and his excellent staff on board the "Challenger," I am sure I only anticipate your wishes by giving expression to the thanks that are due to him for his very interesting lecture.

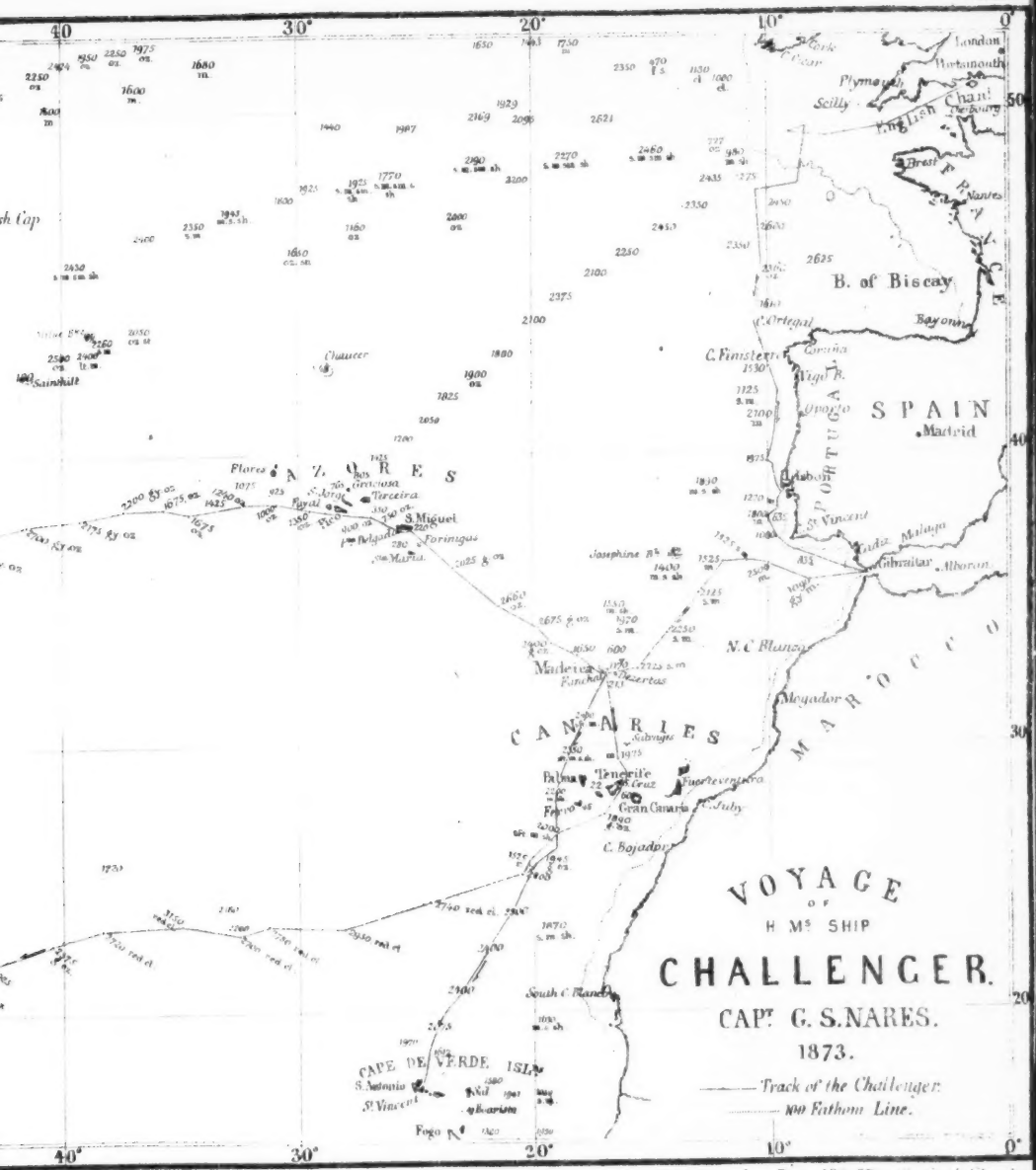
EXTRACT FROM A PAPER READ AT THE "BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE," AT BRADFORD, BY CAPTAIN J. E. DAVIS, R.N., ON "THE SCIENTIFIC VOYAGE OF THE CHALLENGER."

(*Appended at the request of Dr. Carpenter.*)

THE "Challenger" has now accomplished a natural division of her important voyage, as she has passed out of the North Atlantic into the South. From England she went to Lisbon, Gibraltar, Madeira, and Teneriffe. From the Canary Islands to Sombrero and St. Thomas'.


CANADA
UNITED STATES
NEW BRUNSWICK
NOVA SCOTIA
NEW FOUNDLAND
G. of St. Lawrence
G. of Maine
Bank of Newfoundland
Flemish Cap
Bermuda
HAITI
Quebec
Montreal
Boston
New York
Delaware
Halifax
St. Johns
Belleisle Str.
Bona Vista B.
C. Breton
Pr. Edward
Sable I.
George Bk
C. Cod
Sainthill
Guadeloupe
Bird I.
St. Thomas
Sta. Cruz
Antigua
Sombrero
Virgin I.
Watling I.
Mariguana
70°
60°
50°
40°

I. K. Davis.



Photographed by Johnston & Hoffman, 402 New Oxford Street.

From St. Thomas to Bermuda, then across the Gulf Stream towards New York and to Halifax. From Nova Scotia back to Bermuda, and then across the ocean to the Azores, and from the Azores to Madeira and Cape Verde islands, from which place the last accounts were received. My remarks, therefore, will be confined to that division.

The labours of the voyage may well be considered dualistic, viz., those of the natural science department and that pertaining to hydrography. I shall confine myself to the labours of Captain Nares and his nautical and hydrographic staff, leaving those of Professor Wyville Thomson and his natural science staff to others more conversant with the subject than myself; and although admitting the vast scope of the Professor's labours, I claim for the one branch equal importance with the other, for it is obvious to the most casual thinker, that the skill (which may be considered a branch of practical science in itself) required in getting a correct depth of the ocean at 3, 4, and 5 miles, to dredge or trawl in equal depths, to obtain a complete series of temperatures at different depths, fixing positions, measuring meridian distances, and other hydrographical work—and this apart from the usual toil of the navigator and seaman—is no ordinary manual labour; and if the mass of ooze brought up by the dredge would, from want of knowledge of natural history, be useless to this branch of the expedition, it is equally clear that the deepest knowledge of natural history lore would be similarly useless without the skill that brings the "grist to their mill;" therefore I think I am quite correct in claiming equal importance for the two divisions of work.

The "Challenger" sailed from Portsmouth on the 21st December, and on her passage down channel and across the Bay of Biscay, encountered the weather very generally met with at that season of the year; however, it settled things down and shook everything into its place, and fortunately, as sounding was impracticable, the ground over which they passed had been previously examined, so there was no loss of time.

The first deep sounding in 1,125 fathoms off, but to the southward of, Cape Finisterre was not very successful, for the line parted when heaving in, and a thermometer was lost; nor was the first attempt at dredging more so; the dredge certainly came up, but bottom up, so the result was *nil*. The second trial proved more successful, and some bright-coloured star fishes and other animals were brought to light. Another attempt at dredging was made in nearly 2,000 fathoms, but whether it fouled the Gibraltar and Lisbon cable or a rock, it mattered little, for after trying seven hours to extricate it, the rope broke and the dredge was lost.

The "Challenger" reached Lisbon on the 3rd January. The King of Portugal visited the ship, and the ship sailed on the 12th.

One part of the duty in deep sounding is to ascertain the true depth of the ocean, and another part to remove bad or doubtful soundings and *vigias*. A *vigia*, a word from the Spanish, is a reported danger in mid-ocean. A piece of wreck with the sea breaking over it, a vessel bottom up, or even a patch of weed, has often been reported as a rock by some captain, seen by him, perhaps, through fog or in thick

weather, and it takes its place on the chart; once there, it remains sometimes for years, to the terror of the navigator, until a few casts from a deep sounder in the vicinity, and a careful look out in passing and repassing the supposed danger, causes it to be expunged from the charts. In respect to doubtful soundings, the difficulty is greater, as may be imagined. On leaving Lisbon, the "Challenger" sounded in the vicinity of two of these doubtful soundings, two rocks of 370 and 423 fathoms, and obtained 1,270 fathoms near them, and 1,380 between them; and although the presumption is that they do not exist, still from what I shall have to remark as I go on, it would be almost presumption to assert it, and an instance occurred the next day to bear me out in this, as in dredging off Cape St. Vincent, where the dredge was let down in 525 fathoms, the ship quickly drifted into 900 fathoms, so steep was the incline.

From Gibraltar the "Challenger" proceeded in a westerly direction, in order to get on the direct line between Lisbon and Madeira, as laying a telegraph cable between the two places had been contemplated, and the soundings on that line were required for it. It will be observed that much deeper water was obtained on the way out, than at the extremity of the line. In 10° west, 2,500 fathoms were obtained, while 60 or 70 miles west of it, only 1,500, while still shoaler water is found outside. This would lead to the hypothesis that another, but submarine, basin exists, similar to those of the Mediterranean and Black Seas, having an outlet between Madeira and Canary islands; and the sounding afterwards obtained of 2,400 fathoms, almost midway between the islands, would add to the probability of the inference being correct. A more minute examination of the vacant space between the African coast and the existing line of soundings would be most interesting; and could the contours of this sea be drawn, with Madeira on the one hand rising some 13,000 to 20,000 feet above the neighbouring land, and Teneriffe on the other, towering some 4,000 or 5,000 feet beyond that, how it would dwarf into insignificance our Gibraltar and the noble headlands we now think so much of! On the line of the proposed cable the water deepened to 2,000 fathoms towards Madeira, and that depth was carried close up to the island.

The "Challenger" reached Madeira on the 3rd February, leaving on the 5th for Teneriffe. At Teneriffe a party of the naturalists ascended the peak up to 9,000 feet, and they wished to complete the ascent, but could not prevail on the guides to accompany them.

Leaving Teneriffe on the 14th, a course was shaped to the south-east, and when 57 miles from the Peak, 1,890 fathoms were obtained. At this station the specific gravity of the water from the bottom was less than that at the surface. The weather being fine, the opportunity was a good one for trying Mr. Siemen's ingenious differential resistance coil. It was tested in comparison with the Miller thermometer at 100, 200, 500, 700, 800, and 1,000 fathoms respectively. The difference at 100 fathoms was 2°— in the Seimen's, which gradually changed to 2°+ at 1,000 fathoms. With any motion in the ship, the difficulty in reading off a delicate galvanometer appears to be an insurmountable objection to this otherwise valuable instrument,

and in the absence of the regular thermometers, could not be depended on.

The serial observations of the temperature of the ocean at various depths were now commenced, and as this is decidedly one of the most important objects of the voyage, I may be pardoned briefly describing the *modus operandi* of obtaining them. One thermometer only is secured to the sounding line just above the sinkers to register the temperature of the water at the bottom, but for the serial temperatures, a line is used specially for the purpose, to which a lead is attached. A thermometer is secured to the line near the lead, and lowered 100 fathoms, then a second, and at 200 fathoms a third, and so on, as many as prudence dictates to trust the line with—as each thermometer is secured to the line, the indices are set. The line is let out to 1,500 fathoms, and then hove in. As the thermometers come up they are carefully released from the line, the indices read and entered in a book, with the corresponding depth and number of the instrument. The operation is then repeated until the series is complete. In some localities, as in the Gulf Stream, these temperatures are taken towards the surface at every 50, 25, or even 10 fathoms, but the serial temperatures have not been carried beneath 1,500 fathoms, as it will be seen by the sectional drawings that the temperature decreases but little from that depth to the deepest water, so that for all practical purposes it is sufficient. The observations, in all cases, have been taken at the same relative depths, so that conclusions can readily be drawn from them by analogy.

As might be expected, in the vicinity of volcanic islands, there were great inequalities in the bottom, and 50 miles outside, a depth of 1,945 fathoms, 1,525, and near that, to the southward, 2,220 were obtained, showing some steep acclivities and depressions. The bottom specimens brought up, coincided with the soundings; from the shallower sounding, stones, sand, and shells were brought up, whilst from the others, globegerine ooze.

The water deepened to 3,150 fathoms at two-fifths the distance on the section, and then shoaled to 1,900 at three-fifths the distance, deepening again gradually to 3,000 fathoms 300 miles from Sombrero; thus there appear to be two deep basins or valleys with a rise between them, and agreeing in contour with a few soundings obtained more to the southward. The section from Cape Verdes to Bahia will be most interesting in connection with this part of the voyage and the two deeps found.

Another point of observation in this line of soundings is in the nature of the bottom; in all the soundings exceeding about 2,700 fathoms the bottom is red clay, while in the shoaler water of the bank between, it is ooze, and I cannot but think that this circumstance, though apparently trivial, will have an important bearing in the consideration of the physical condition of the deep. At one sounding on this line, that taken on the 21st, in 2,740 fathoms, the sounding rod when it came up, was found to be entangled in the first 100 fathoms of line, that quantity having been paid out after the weights were down. This proves that the bottom water at that time must have been per-

fectly still, and that the rod must have been sticking upright in the mud at the bottom.

On the 14th March, in 1,900 fathoms, the hempen tangles attached to the dredge brought up, what Dr. Wyville Thomson calls, a "handsome decapod crustacean." I should probably call it an overgrown prawn, about 5 inches long—its generic name is "Deidamia leptodactyla"—but my object in mentioning it, is in the remark that it had no organ of vision, indeed no eye-stalks. Now, without getting away from my subject, it will be a nice question as to where the use of eyes ceases in ocean animal life. It certainly will not depend on the penetration of light through the ocean depth, as Dr. Carpenter brought up animals with *well developed* eyes, from a depth where no one can pretend to say there could be light; and if I remember rightly, phosphoric agency was brought to bear, to account for it; but I must not get out of my depth in the natural history department, but Professor Wyville Thomson mentions many strange anamolies in ocean animal life, which doubtless will be well considered on the conclusion of the voyage. Permit me, without further comment on this line of sounding, to bring you to an anchor at once at St. Thomas; this occurred on the 16th March.

An examination of the deep-sea-temperatures between the Canary Island and the West Indies is interesting. They show a stratum of water of equal temperature of 49°, at a uniform depth of about 380 fathoms, the water above gradually increasing in temperature, and that below decreasing. The temperature at the bottom varies but little, it being 35·6° on the African, and 34·9° on the other side of the Atlantic.

On the 24th the "Challenger" was again under way for Bermuda, first taking some soundings, and dredging in the immediate vicinity of the islands, and then stretching away to the northward towards Bermuda.

On the 25th, when only 80 miles from the land, a sounding was taken of the greatest known depth in the world, viz., 3,875 fathoms (nearly 4½ miles); not imagining that so near the islands so great depth of water would be found, only 3 cwt. of sinkers were used with the Hydra-machine, two thermometers and a water bottle were attached to the line. The line was 1 hour 12 minutes in running out, the last 100 fathoms taking 3 minutes 18 seconds: the progressive time intervals here proved of great value. The small dredge was let down, and this extraordinary depth was dredged with 5 miles of rope; the dredge on coming up brought a small quantity of mud, but with little sign of animal life.

From this deep sounding, the water shoaled 1,000 fathoms, at a distance of 110 miles, and then continued without any great alteration until close to Bermuda, at which place the "Challenger" arrived on the 4th April.

The several deep soundings taken around Bermuda, prove it to be a peak on which the coral animals have built the islands; and from the fact of there being considerable magnetic disturbance at different stations on the islands, it may be inferred that, unlike the coral formations of the Pacific, there has been no subsidence of the mountain. There are two or three other peaks similar to that of Bermuda, for

instance, the Sainthill and Milne banks, one with 100 fathoms, the other with 80 fathoms on it. These are well authenticated soundings, and had the peaks been a few fathoms nearer the surface, doubtless we should have had two islands similar to Bermuda.

The "Challenger" left Bermuda on the morning of the 21st April, and soundings were taken in the immediate vicinity of the island. On the 24th, when 45 miles to the westward, after sounding in 2,650 fathoms, and when the dredge was at the bottom, a boat was lowered and anchored by the dredge, and the surface current was ascertained; the currents at different depths were then tried down to 600 fathoms; a movement was found to 500 fathoms, but the observations varied so much in direction and force, as to preclude any deduction from them. They were again tried 200 miles to the north-west with more uniformity both in direction and force.

Proceeding to the north-west towards New York, the deepest water, 2,850 fathoms, was found about midway between Bermuda and the southern edge of the Gulf Stream. Soon after noon on the 30th, this southern edge was crossed, the temperature of the surface-water changing suddenly from 65° to 72°; a sounding of 2,425 fathoms was obtained just before it was reached. On the 1st May, being in the middle of the Gulf Stream, great interest was evinced in the day's work. The temperature of the surface-water had here increased to 75°. The preparations for sounding were made with great care—4 cwt. of sinkers were attached to the line, and in lowering them into the water, a strong current at once became evident, setting to the E.N.E., which necessitated the ship being steered to the W.S.W. at the rate of three miles an hour, in order to keep the line "up and down;" each time the line was let go, the bight went astern on the surface; the line was then held from running out, until it was again up and down, when it was let go again to be checked after another 100 or so fathoms had run out, this of course rendered the time-intervals of no avail. At 1,800 fathoms, the line carried away, and another trial was made, and after 2,600 fathoms had run out, supposing it had reached the bottom, it was hove in, but the weights had not disengaged, and there was no sign on the rod that it had touched; it was therefore only recorded as a "no bottom" sounding. The current-drag was then lowered 100 fathoms, and the surface-current passed the watch-buoy at a very slow rate; at 350 and 400 fathoms, the surface-current ran past it at the rate of a mile and three-quarters an hour, so that probably at that depth there was no current, as the current of from three to four miles an hour acting with great power both on the watch-buoy and on the line to 100 fathoms, would be sufficient to move the current-drag at the rate to make up the difference. From some serial temperatures taken in the afternoon, it was considered that the Gulf Stream at this position did not extend beyond 100 fathoms in depth, for after that, the water got rapidly cold, showing that a mixture of the Labrador current and the regular warm water of the Bermuda regions was taking place.

Conclusions were also drawn from these and other observations, that at this section of the Gulf Stream, it is 57 miles wide and 100 fathoms

deep, that the rapid current was only on its western edge, and did not exceed a breadth of 15 miles, that the rate of the current is 3½ to 4 miles an hour, and that the temperature of this belt of rapid current exceeded by 3° the other parts of the stream. On reaching the edge of the bank extending from the continent, the course was changed, and soundings taken to the southward of the bank towards Halifax.

On the 19th May the "Challenger" left Halifax on her return voyage to Bermuda; on the 22nd she sounded close to the position of the Hope bank, on which there is said to be only 49 fathoms; but no indications of it were found. On the 23rd the Gulf Stream was re-entered, and a sounding obtained of 2,800 fathoms. The next day the warm water of the stream was found to extend only 50 fathoms down. From the southern edge of the stream the depth remained about the same, 2,600 fathoms, to Bermuda.

In the return voyage across the ocean to the Azores, there is not much to comment on: the water suddenly deepened to 2,360 fathoms at a distance of 60 miles from Bermuda, and then gradually to 2,850: the deepest water, 2,875 fathoms, being one-third the distance from Bermuda. It then very gradually shoaled the next third, and then more suddenly towards the islands from 2,000 to 1,000 fathoms, which latter depth was carried close up to Fayal. The trawl was let down at the deepest part of this section, and from this tremendous depth, many star-fishes, sea-slugs, and worms were successfully brought up. From the cast of 2,175 fathoms, a hermit or soldier-crab was brought up, and from a similar depth, a remarkable crimson prawn, which I doubt not is safely pickled and will be brought home, and I may remark that a small turtle was caught, covered with barnacles and small crabs; he must have been some time at sea, and was decidedly out of his latitude, the barnacles and crabs were doubtless also pickled, but I am reasonably doubtful if the turtle was.

On the 27th June, when about 220 miles from Flores, observations for sub-currents were again made, with the same incongruity of direction; for while the surface current set to the southward, that at 50 fathoms was S. 59° E., and at 100 fathoms N. 82° E., but the serial temperatures denoted a remarkable change in the iso-thermal lines, evidently owing to the under current; the trawl, on coming up, was found entwined round the spar, and 25 fathoms of rope foul of the spar, this was attributed to the strong under current.

The "Challenger" reached Fayal on the 1st July, but small-pox being prevalent on the island, did not remain, and proceeded to St. Michael, where her inmates recruited, and for the few days they were there, greatly enjoyed the beauties of that beautiful island, of which, comparatively, so little is known. Leaving St. Michael's on the 9th, soundings were taken to Madeira, the depth being tolerably even at 2,600 fathoms, rising towards the islands. From Madeira, a course was shaped direct for Cape Verde Islands, passing westward of the Canaries. Midway between Madeira and Palma, 2,400 fathoms were found, while southward of the last-named island, only 2,000 fathoms were obtained; but midway between the Canaries and Cape Verdes, it increased again to 2,400 fathoms, shoaling again to 2,000 towards the

westernmost of the Cape Verde Islands. The "Challenger" reached St. Vincent on the 27th July.

I have not attempted to go into the detail of all the soundings taken, nor have I stated when and what serial temperatures were taken, and where dredging and trawling were carried on. Did I attempt it, it would sound but a jumble of statistics without imparting knowledge. I can only touch the leading and most striking features of the voyage, leaving to the student the careful consideration of the iso-thermal diagrams, which teem with interest in regard to the movement of the "great waters."

In thus sketching the work accomplished by the expedition in the first seven months of her voyage, but a poor conception can be had of the labour, trouble, and anxiety attending its execution. To summarise it is impossible, but without taking into account any soundings taken under 1,000 fathoms, 48 were taken between 1,000 and 2,000 fathoms, 56 between 2,000 and 3,000, and 4 exceeded 3,000, and in these 108 soundings, there was only one miss. In sounding alone, 243 miles of line have been run out and hauled in again. At about 60 stations, either the trawl or dredge was let down, and the quantity of rope veered out was from one-third to one-fourth more than the depth of the water. At upwards of 50 stations, serial temperatures were observed, generally at every 100 fathoms to 1,500, and these supplemented by many intermediate observations between. Near the surface the quantity of line veered out and hauled in again for these two purposes, it is impossible to estimate, and this has been the work of the nautical branch, irrespective of magnetic, hydrographic, and (I suppose we must call them) meteorologic observations.

The accompanying chart of the "Challenger's" route, with soundings, &c., is inserted with the kind permission of the proprietors of "Ocean Highways," a journal devoted to geographical record.

Evening Meeting.

Monday, January 27th, 1873.

CAPTAIN J. G. GOODENOUGH, R.N., in the Chair.

NAMES OF MEMBERS who joined the Institution between the 21st and 27th January, 1873.

LIFE.

Leask, William, Capt. 22nd Essex Rifle Volunteers.

ANNUAL.

Llewellyn, W. R., Major R.A.
Treffry, Frederick, Assistant Paymaster Control Department.
Martin, F. S., Ensign late 58th Regt.
Chamberlaine, T. J., Lieut. Ceylon Rifles.
Gardiner, A. M., Lieut. R.N.
Gordon-Cumming, Sir W. G., Bt., Capt. Scots Fusilier Guards.
Burls, E. Grant, Capt. 1st Surrey Art. Volunteers.
Stuart, W. T., Capt. Bengal Staff Corps.
Thornhill, H., Major Royal Horse Artillery.
Pamphilon, F. W., Lieut. 2nd South Middlesex Rifle Volunteers.

A PROPOSED METHOD OF MOUNTING HEAVY ORDNANCE AT SEA ON THE PRINCIPLE OF THE BESSEMER SALOON.

By Lieut.-Colonel A. STRANGE, F.R.S., Inspector of Scientific Instruments to the India Government.

A SHORT time ago, two letters from me, bearing the title of "*A Ship of the Future*," were published in the *Times* newspaper.* In these letters I made the proposal indicated by the title of the present paper. The proposal appearing to the Council of this Institution worthy of further consideration, they did me the honour to beg me to prepare a paper on the subject, a request with which I felt bound to comply. I undertook the task, however, believing that more light would be thrown on the questions to be mooted by the discussion which they will, as I hope, undergo at the hands of accomplished Naval and Military Officers and Engineers in this theatre, than by the contents of the paper itself.

It is not without misgivings that, as a landsman, I venture to address seamen on naval guns and ships of war, and I must, at the outset, bespeak their indulgence for my inevitable shortcomings whilst struggling in a foreign element, and beg them, if I should happen to get out of my depth, rather to give me a friendly lift than force my

* 30th November and 6th December, 1872.

head under water, yielding me credit for at least honesty in my endeavour to contribute something to the most difficult and the most important national problem of the day.

So many descriptions have lately appeared of Mr. Bessemer's contrivance for giving stability to the saloons and cabins of Channel passenger ships, that I think I may, in order to economise time, take for granted that the main features of his arrangement are pretty generally understood by such an audience as this. The idea of mere suspension to counteract a ship's motion is probably as old as the idea of ships themselves. But mere suspension, as every one knows who has observed a binnacle compass, or a hanging lamp at sea, is insufficient to secure perfect quiescence. The point of suspension itself partakes of the general motion of the ship, and this communicates always an independent swaying motion to the suspended body. Various frictional devices have been adopted for the purpose of lessening this swaying motion, the success of which have been, and could only be, partial. Mr. Bessemer is the first, so far as I know, who has gone to the root of the matter, and devised appliances to arrest these swaying movements, by means of an active external force under the control of human agency. Many mechanical contrivances are applicable to the purpose, but probably none would equal in simplicity, sensitiveness, durability, facility of manipulation, and power, the peculiar hydraulic apparatus which he employs. In his Channel ship, he has applied his invention to counteract only the rolling motion of the ship; but he has stated publicly, what cannot be doubted, that the same arrangements can be applied to counteract the ship's pitching motion also. Mr. Bessemer has recently shown me his large collection of elaborate drawings, illustrative of his labours on this subject, many of which exhibit clearly a variety of ways in which cabins and saloons can be suspended and controlled in two rectangular planes, so as to counteract both rolling and pitching.

Assuming that this can be done in the case of a large ship's saloon, it appeared to me,—the moment I saw Mr. Bessemer's great working model,—that, by the application of the same principles, the platform of a naval gun could equally be kept horizontal. I accordingly threw out that suggestion in a letter to the *Times*, and Mr. Bessemer immediately wrote to the same journal,* approving of it, and adding that, "he does "not hesitate to say that all Colonel Strange has proposed is perfectly "capable of realization." It is here right that I should mention that Mr. Bessemer, whom I had then only met once in my life,† gave me full credit, in very handsome terms, in the letter above cited, for the originality of my suggestion. Justice, however, requires that I should add that he has since shown me the specifications and drawings of his patents relating to suspended saloons, and that these contain distinct allusions to the applicability of his invention to the mounting of Naval guns. An act of spontaneous generosity such as this is too rare to be passed over without full and public acknowledgment.

* 3rd December, 1872.

† I may further mention that I am in no way connected with Mr. Bessemer by any pecuniary interest, nor am I a shareholder in the Bessemer Saloon Company.—A.S.

The great advances which, within a comparatively recent period, have been made in the construction of ordnance by the introduction of rifling, in the forms of projectiles, in the manufacture of explosives, and in theoretical gunnery, have been, to a great extent, lost to the Navy; the movement of ships, even in moderate weather, being fatal to what on land would be considered accurate fire. If we take a quarter of a mile for the distance of the enemy, as our standard of comparison, a distance at which very accurate practice is made on land, and 10° for the angular roll of the attacking ship, we find that the maximum deviation of the shot will be 230 feet, or from 10 to 15 times the width of the object fired at. This deviation increases or diminishes directly as the distance or the angle of motion, and may, therefore, readily be deduced for any given case by bearing the above numbers in mind. The mode of firing at sea may be briefly described, in general terms, as follows:—The sight having been adjusted for the assumed distance, the gunner watches the range of the gun; at one extreme of the ship's roll he sees it pointing far above the enemy, at the other far below, and he fires the gun at the moment when he considers it to be midway between these extremes, pointing at the enemy. If the roll is small and slow, the right moment may be seized by a skilful man with some approach to certainty; but when it is large and quick, any success which may reward his endeavours must be, in a great measure, a matter of accident. No doubt cleverness, constant training, and long experience, will do wonders with this primitive system of snap-shooting, but it is difficult to understand how any one can maintain, as some do, that no advantage is to be expected from arrangements which, if practically feasible, will substitute comparative certainty of fire at sea, for a system largely partaking of chance.

I have endeavoured to obtain data for estimating the degree of accuracy now attainable at sea under ordinary conditions of weather, but have not been successful in discovering any extensive series of well-considered and satisfactorily-executed experiments on this problem; but in the course of preparing these notes, I have re-perused a paper by Captain P. H. Colomb, R.N., on "The Attack and Defence of Fleets," published in vol. xv of the Journal of this Institution, which bears upon it, and as the author of that paper, with whom I have not the pleasure of being personally acquainted, is looked up to as one of the most scientific officers in the Navy, I cannot do better than quote some of his remarks on the subject before us. He says:*—"Unfortunately, "precise figures are wanting here, and very little attempt has been "made to obtain them, as they can alone be obtained by experiment. "The inquiry takes the form of two questions: *How many shot* will "strike the 'Monarch' *in a given time in the open sea*, and what amount "of damage will they do? And I must own it has struck me as "alarmingly suggestive that I cannot get an answer off-hand to *either* "*query*. Nobody seems to have made the calculation, even with such "data as are obtainable, and no steps have been taken to improve the "data. It is true, I believe, that the materials for determining the

* Page 411.

"number of shots which will strike a given vertical target at a given "range, when fired *from a steady platform*, are obtainable, but such a "determination must be a very fallacious guide as to the *results at sea*; "nor am I sure that even the materials obtained have been applied to "determine the practical question." This paper was read on 3rd April, 1871. I have not been able to ascertain that our knowledge has since made much progress regarding one of the two questions here referred to by Captain Colomb, namely, accuracy, with which alone we are at present concerned.

Captain Colomb then proceeds to discuss, with his usual ability, the meagre data in his possession, and finally arrives at the conclusion thus expressed:—

"I must make a reasonable assumption on the facts I am possessed "of, and state a mean position between the result deduced from the "Vigo experiment and those taken from prize firing, and I lay it "down that 10 per cent. of the 'Monarch's' shot will strike a "'Monarch' in action at 1,000 yards."

Now I think all must admit that such a result as only one shot in ten hitting at 1,000 yards, proves that we have here a very wide field for improvement. It is clearly and ably shown by Captain Colomb, that into modern naval warfare, time will enter as a powerful element, and time is obviously identical with accuracy, other things being equal. It is scarcely necessary, however, to insist on what is on every hand admitted, not merely by naval artillerists, but perhaps even more explicitly by naval architects, one of whose main objects for years has been to confer on vessels of war the steadiest possible platform. As it is well known that maximum steadiness of platform is not combinable with maximum stability or safety from capsizing, the endeavour to realize these antagonistic conditions has cost our naval constructors the greatest anxiety, and contributed to, if it did not directly bring about, the terrible loss of the "Captain."

My present paper is, according to its title (which I may mention is in the exact words prepared, not by myself, but by the Council), but a "proposal," and makes no pretence to be a demonstration. It would be quite impossible, or I should rather say entirely beyond the scope of my ability, to give in the course of one hour a complete demonstration of what is an intricate problem, almost indeterminable for want of data, and also to place fairly before you the consequences flowing from its solution.

I must therefore put my case hypothetically rather than argumentatively. I must take a great many things for granted, and base my proposal on postulates in default of proofs. But when you come to know the extreme moderation of my proposal you will, I think, allow there can be no great objection to its adoption. My postulates, or, if you will, my assumptions, are—

1. That increased accuracy of fire at sea is very desirable.

2. That such accuracy is at present defined less by the precision of our naval guns, than by the unsteadiness of their platform.

3. That steadiness of platform has hitherto been sought by means of modification of the ship's external form only.

4. That steadiness of platform, so sought, is limited by considerations of the ship's stability or safety from capsizing.

5. That hence, if the demand for steadiness of platform can be complied with by internal appliances, naval architects will be unfettered in their endeavours to give the maximum stability and sea-worthiness to ships of war.

6. That Mr. Bessemer's system of controlled suspension is applicable as a means of securing a high degree of steadiness of platform by internal construction.

The definite proposal I now make is, that this controlled suspension should be put to the test of careful and impartial trial. There would be two main points to test: First, whether Mr. Bessemer can, as he has said both publicly in the *Times* and privately to myself, that he can, design mechanism fitted to carry heavy guns on board ship, and to maintain the horizontality of their platforms, even in bad weather, within an extreme range, in any plane, of one degree; and secondly, whether with guns so mounted, the accuracy of fire will be much greater than under the present system. As to the first point, the illustrations and explanations of Mr. Bessemer satisfy me that, though there will be many difficulties to overcome, on which, as matters of detail, I have no time to dwell, he will succeed in the undertaking.

As to the second point, I can only express my anticipation that the result will be a very great advance in naval gunnery, calculated to bring out, and turn to effective account, the enormous improvements which have in modern times been made in artillery implements of all kinds. But it is evident that the introduction of a gun platform devoid of sensible angular motion, will necessitate a radical revision of our present system of naval gunnery, amounting to a revolution; and as it may be some time before the drill best adapted to the new system, is settled, and men thoroughly trained to perform it, the whole of the good effects of steadiness of platform may not immediately show themselves.

One part of the drill which I apprehend will undergo a total change will be that vertical aiming by eye along the sights of naval guns will be, under all ordinary circumstances, dispensed with. Since gravity, assisted by Mr. Bessemer's hydraulic apparatus, supplies a practically permanent horizontal plane, the gun may be set vertically to the elevation required by the distance of the object (in any case supposed to be known approximately), and the moment for firing will be intimated by a spirit level, the indications of which can easily be conveyed by optical expedients, to any part of the ship in which it may be most convenient to post the man appointed to fire the gun, electricity being of course employed for firing it. The horizontal direction or training of the gun will, in the case of bow-firing, which seems every day to be advancing in favour, be given by the man at the helm, and the truth of the alignment can be conveyed by optical means to the same field of view as that in which the indications of the horizontal spirit level are made visible to the gunner charged with the duty of firing.

It is right that I should here mention that Mr. Bessemer foresees another solution of the problem of accurate firing. He proposes to add

a peculiar apparatus, invented by himself, which shall enable the gun to fire itself automatically at the very moment when it shall have been brought by the motion of the ship, unaided by any suspension arrangement, to the vertical elevation required by the distance of the object. The apparatus in question of course fires the gun by means of an electric discharge. I shall not attempt to describe its details, but shall leave that for Mr. Bessemer to do when and how he sees fit. But I have examined it, and believe it will act efficiently in the case of a broadside gun, which is subject principally to one motion only, namely, the vertical motion caused by the rolling of the ship. I am doubtful whether in its present form it will do for bow guns, which, being affected by the pitching as well as the rolling of the ship, are subject to very complex movements, rendered the more so by the fact that the most energetic of them, the rolling, is perpendicular to the line of fire, and takes place round an axis not coincident with the axis of the gun.

Mr. Bessemer's self-acting igniter is, however, eminently deserving of trial. I am disposed to think that a combination of this with the controlled suspension will be better than either, separately, for bow guns.

The trial of these two contrivances need not be an expensive undertaking, and the object sought to be obtained with them, fully justifies its cost. The result to be aimed at, should be more of a comparative than an absolute character. Hence the two systems, the old and the new, should be pitted against each other. To do this, two ships should be employed. The one representing the old system should, in order to give it fair play, be of a build giving a reasonably steady platform. The ship carrying the new appliances may be a good sea boat of ordinary build. The guns, projectiles, and powder in both should be absolutely identical in every respect; and, in order to eliminate unsuspected differences, the guns should be interchanged frequently. Practice should be made in all weathers and at all distances. The gunners employed for working the old system should fairly represent the skill of the day, and those employed for working the new system should be placed for instruction under its advocates or representatives, and the experiments be tried under their supervision.

I will now, for the sake of argument, anticipate the result, and assume it to be decisively favourable to the new system, and will proceed to inquire what would be the consequences of such a result.

First, it can hardly be doubted that, if by means of these contrivances, we can make at 1,000 yards, say six or eight hits in ten instead of only one in ten, which Captain Colomb estimates to be the present practice, it will be expedient to apply them in existing armour-clad ships. We shall then have combined the maximum attacking with the maximum defending power in the same vessel, and have thus,—supposing these contrivances productive of no inconveniences with regard to internal arrangements,—undeniably improved her as a fighting machine. The fair probability of such a result would certainly justify the moderate cost of testing these appliances experimentally.

But may we not extend the range of our thoughts, and speculate on

the possible influence of accurate firing at sea in all weathers on the great problem of the construction of our ships of war?

It is of no use to cry out against another reconstruction of our Navy, another there will be, and another and another, until the restless brain of man sinks to repose, or the secrets of nature have been exhausted. It will not do to say "let well alone," where nothing is settled, nothing is well. It will not do for England to wait to see what other nations are doing, and "govern herself accordingly." In Naval supremacy at least, whatever she may do in other matters, she must lead if she is to exist. On no point, on no question of policy, are Englishmen so perfectly unanimous as on this, that their Navy must be the most advanced in efficiency, and the most powerful in the world. Self-interest, prejudice, excusable love of old and hitherto successful expedients, financial considerations, must all yield to the well-grounded conviction that, until that happy but apparently remote period arrives, when the lamb shall lie down with the lion, the vast dominions under the British Crown can be secure only on the condition that our Navy is supreme on earth.

And here I must give voice to the feeling which oppresses many a thoughtful Englishman,—that Naval questions are made too much a political battle-field. Of this dangerous tendency we have had but recently some lamentable examples, on which, in this Institution, it would not be proper for me to dwell. But it is impossible for one independent of political shackles as I am, to approach the subject on which I am addressing you without looking back to the party contests which it has almost invariably provoked, and without protesting against the unpatriotic and dangerous subordination of imperial, to individual and political, interests, which has so often interfered with sound decisions on the paramount problem of Naval construction. Against this hindrance, when it exists, it is impossible for reasoning to prevail, and the consequences must be on the heads of those who cause it.

But there are other hindrances besides. Self-interest of a narrower kind, sometimes in a simply sordid form, sometimes with pardonable features. Certain engineers, inventors, and manufacturers, represent one class who have benefited enormously by the course which Naval construction in late years has taken, and who would naturally, though selfishly, resist any change calculated to lessen or divert their accustomed profits. Another class are official men and Naval Officers who have attained honourable distinction by their mastery of existing methods, and who are excusably loth to go to school again. A Naval Officer, for instance, who had served chiefly in large armour-clads, and had attained well-deserved eminence in handling them, could not reasonably be expected at once to acquiesce in the abandonment of the floating fortress in which he had justly taken such pride.

Even, therefore, if I could demonstrate the necessity for a reconsideration of the whole subject of Naval construction, I well know the tremendous resistance which political considerations, pecuniary interests, official prejudice, and professional preferences would oppose to the acceptance of the plainest truths. Still, believing, as I do, in the ultimate prevalence of truth, and knowing that the sooner it is

enunciated, the sooner it will be accepted, I shall not be deterred by any amount of possible opposition from stating what I firmly believe to be the case, namely, that the star of armour-clad ships has reached its culmination, and that it will henceforth decline.

In the short space of time at my disposal, I can only broadly state the grounds on which I hold this belief. First, the instinct of the nation has gradually become more and more apprehensive of these ships. This feeling probably dates from the terrible loss of the "Captain." Suddenly the fact was forced upon the public mind that a recent and costly invention had dangerous properties which no one, not even the lamented inventor himself, had foreseen; and the conclusion, however exaggerated, became general, that in ship-building for the Navy we were groping in the dark. Not only is the comparatively uninstructed public mind uneasy, but the professional mind also, with of course numerous exceptions, is far from being assured. Nothing, since the "Captain" disaster, has occurred to allay this uneasiness; on the contrary, we every day hear of some new form of dangerous activity, or as dangerous inertness, peculiar to this race of ships. And no sooner is a new specimen of the race brought into the world than, even amongst sailors and experts, there is at once a shaking of heads and a shrugging of shoulders. Will she steer? Will she stem the Atlantic waves? Dare she move an inch out of smooth water? Has she not required hundreds of tons of ballast to keep her upright? If masted, how much sail can she carry in a gale without capsizing? If unmasted, how will she behave in an Atlantic storm, with her engines disabled by accident, or her coal exhausted? And in action, how will she fight? Will her armour, after all, preserve her against every possible antagonist? And then what did she cost? What fraction of the national defences does she represent? Are we sure the cost has secured us what we want,—safety in all weathers, victory in every fight? And finally, costing so much as she has done, how many such can we afford to possess, and will they be sufficient for every requirement, for the defence of our enormous and scattered possessions, and our gigantic commerce?

These are some of the innumerable questions that are current in society, and that must pass through the mind of every thoughtful man who, without pretending to study the subject seriously, yet keeps himself informed by means of newspapers, periodicals, and lectures, of its salient features.

Those who go a little deeper, and read the Parliamentary reports of official inquiries, and associate with persons professionally or departmentally engaged in Naval affairs, find stronger evidence still of the doubts and the difficulties which shroud the tremendous subject. The first and great fact by which, at every stage of their inquiry they are arrested, is, that those engaged in providing a Navy for the country, are divided into two main camps, irreconcilably hostile to each other—the artillerists and the armour-platers. These rarely, if ever, unite for the common object of producing the best total result. The artillerist simply despises the armour, and tells you he can produce a gun to pierce any you can make your ship carry; and the armour-plater

retorts that many of the solid shots will glance, some break up without penetrating, and most miss altogether, whilst all the dreaded shell will be kept out; and that, when it comes to close quarters, no ship can withstand the armour-clad's ram.

The Report of Lord Dufferin's Committee on Designs of Ships of War, is not calculated to re-assure the reader. I have endeavoured to arrive, for my own satisfaction, at the net result of that inquiry, and after weighing as impartially as I can all the contradictory opinions of witnesses which it contains, and the hesitating tone of the two Reports founded thereon, I have come to the conclusion that a feeling of uneasiness as to the safety and sufficiency of armour-clads permeates the whole of these voluminous documents. A critical analysis that would justify this judgment would itself fill a volume. There runs through the whole, where the tone is not absolutely condemnatory, a strain of deprecatory exculpation which left on my mind the impression that even the avowed advocates of armour had latent misgivings that they did not dare own even to themselves. It is to be noticed, too, that few, if any, of the sailor witnesses or Committee-men ventured to grapple with the question of the safety of certain new armour-clads. This awkward problem was left, by common consent, to two distinguished mathematicians, whose conclusions are as remarkable for caution as their investigations are for ability.

I will give a few brief extracts from the Report (from which, however, Admirals Elliot and Ryder dissented on many points), which will, I think, fully justify the general conception I have formed as to its tendency.

At page ix we find this passage:—

"Hitherto the powers of offence, represented by artillery, and of de-
"fence, by armour, have advanced almost *pari passu*, sometimes one,
"sometimes the other, slightly in advance; but we appear now *to be*
"*closely approaching* a period when the gun will assert a *final* and
"definitive superiority."

In the next page (x) we find the Committee doubting whether the above opinion may not have gone too far, in the following words:—

"Even assuming that absolute impenetrability to shot proves to be
"unattainable, it is still our opinion that *the time has not come* to
"throw off armour *altogether*, but that it is necessary that the first
"ranks of our ships of war should continue to carry armour of as
"great resisting power as possible."

I do not quote these two passages for the purpose of fixing a charge of inconsistency on the Committee, on the contrary, they are quite consistent; but to my apprehension they are the words of honest and well-informed men, burdened with a tremendous load of responsibility, brought face to face with the inevitable, and yielding to it with stubborn reluctance. Nor is it wonderful that the Committee should feel apprehensions regarding the approaching supremacy of the gun, when we find them quoting, between the two above cited passages, the assertions of such high authorities as Sir W. Armstrong and Sir Joseph Whitworth, that they are prepared to produce guns capable of penetrating respectively well-backed armour 20 and 24 inches thick (pp. ix

and x). I shall presently have to tell you that another authority of eminence equal to these, is prepared to furnish guns which will throw even these tremendous performances into the shade.

I will now quote a passage from the Report, which bears directly on the immediate subject of this paper, namely, accuracy of fire at sea.

At page xi the Committee say:—

"It is a well known fact that those peculiarities in the design of a "ship which result in what is termed 'great metacentric height,' and "consequent stiffness under canvas, are amongst those which materially "tend to produce quick rolling and to make the ship uneasy in a sea-"way."

"Nothing," they proceed to say, "*is so detrimental as this to the "accuracy of artillery fire*, which, in consequence of the reduction in "the number and increase in the weight and cost of projectiles com-"posing a broadside, has now become of far greater importance than "at any former period. Naval architects have been induced therefore "to seek steadiness of platform by diminishing, as *far as safety would "allow*, the statical stability and stiffness of the ship. In some recent "instances (*e.g.*, the 'Inconstant' and the 'Invincible' class) this was "carried to a degree which, together with an alteration in the distribu-"tion of weights during construction, has led to a considerable weight "of ballast being placed on board these ships in order to correct the "crankness so caused."

Accepting these views with the respect to which their source is entitled, we find these three positions firmly established in the compact passage I have just quoted:—1. That accuracy of fire is of the highest, and of increasing, importance. 2. That the conditions conducive to accuracy, if sought by modifications of the ship's external form, are opposed to the conditions conducive to her safety. 3. That in the endeavour to hit the mean between these antagonistic conditions, the safety of some ships having been compromised, large amounts of dead weight has had to be added.

But then follows a most remarkable sentence in the same page (xi), as follows:—

"But although experience has shown that in these instances the "principle of giving up stiffness to obtain steadiness of gun platform "was carried *somewhat too far* [for safety], it is much to be regretted "that it should be necessary in any degree to abandon *the very impor-"tant object* which the designers of those ships had in view, and *if any "means can be adopted* by which steadiness of platform may be made "to accompany great stability or stiffness, a most valuable result will "have been achieved."

Throughout the whole of this Report and Evidence I have been unable to find any suggestion for uniting the two objects here so emphatically pronounced to be all-important, but by modification of the ship's external form. There is no hint that I have been able to discover that the proposal it is the object of this paper to submit to public discussion, solves a problem which, when the Report was published last year, was inferentially, if not directly, admitted to be then

insoluble, namely, to obtain accuracy by contrivances within the ship, and safety by her external form.

But to revert again to armour. Let us endeavour to fix some landmarks in the wilderness of arguments by which the subject has been obscured.

1st. Is armour in itself, apart from its defensive functions, advantageous to a ship? Will she sail or steam better or faster, or more safely, for having parts of her sides loaded with enormous masses of iron? Need I answer such a question? Armour, then, will do a ship, simply as a ship, no good. It is not likely to be added, for instance, to merchantmen and mail steamers.

2nd. Is the effect of armour on the sea-going properties of a ship neutral? or does it involve, when of extreme thickness and extent, modification of form, increased size beyond what might otherwise be required, and augmented engine power? We know it does bring all these train of consequences. It is then not neutral.

3rd. Does it add to the cost of an individual ship? We know it does, enormously. Has the total number of ships of war possessed by a nation any direct relation to the cost of individual ships? or, in other words, would our Navy have the same numerical strength in ships, whatever their cost? Or again, to put the question in a still more direct form, If it were found that defensive armour could be dispensed with, and that the present attacking force of the English Navy could be maintained for one-quarter what is now spent in defensive ships, should we not, being then able to afford it, largely increase our attacking force? If the answer to this question be not in the affirmative, then either our attacking force is already ample, which is not the general opinion, or we have paid for it *more than we can afford!*

4th. Is armour, if neither advantageous nor neutral, prejudicial to ships carrying it, simply considered as ships? There can be but one answer to this question. Armour *is* an evil.

5th. Admitting armour to be an evil from the architect's point of view, and a very costly evil, tending by its mere cost to reduce the numerical strength of the Navy, what are its properties which induce us to submit to its admitted drawbacks? What are the compensations?

This is the pith and essence of the inquiry. Let us examine it as well as our remaining space will admit. There are at present four known modes of naval attack:—1. By shells. 2. By ramming. 3. By Torpedos. 4. By solid shot.

Will armour, as at present used, keep out all four aggressors? Unless it will do so we are not fully protected by it. Of what avail is it to keep out every form of projectile but one, if that one is irresistible. Let us examine separately the four forms above enumerated.

1. *Shells.*—For argument's sake, I will assume that shells of every form and description can and always will be kept out; an assumption, however, which few artillerists will assent to.

2. *Ramming.*—The contrary assumption may here be boldly made. No existing armour-clad can resist the well-directed ram of a similar vessel. The recent case of the "Northumberland," in which the ram

was delivered accidentally, indirectly, and lightly, settles this question. We know that to inflict the blow in the best manner is difficult. Captain Colomb, in the paper already quoted, explains the theory of that mode of attack, and points out both how to conduct and how to evade it. But one blow, properly delivered by a well-fitted ship, would send her antagonist to the bottom.

3. *Torpedoes.*—These are nearly in the same category with ramming. They are, and probably always will be, difficult to explode at the exact moment and the precise place required; but if so exploded, can anyone suppose that the strongest conceivable ship would resist the eruption of a small volcano suddenly bursting out under her bottom?

Here, then, are rams and torpedoes on the side of the attack against shells on the side of the defence. Let us be fair, and allow, but only for the sake of argument, that the two attacking methods are uncertain, and that the defence from shells is effectual,—so far, then, we have armour on account of shells only, and it may be worth while to retain it and risk the ram and torpedo, which are remote dangers. Then how about

4. *Solid Shot.*—It cannot be doubted that, whilst the difficulties and uncertainties attending the use of the ram and torpedoes will tend to retard their development, there are elements about solid shot which must always encourage inventors to new exertions. Unlike both the ram and the torpedo, solid shot can be delivered from a distance with comparative safety to those using it. Unlike the other two, its reaction will not injure its own ship or her machinery, which ramming will probably do; nor will she run any risk of being involved in the fate of her adversary, as may happen accidentally with torpedoes.

To make solid shot effectual against armour, two things are necessary,—first, that it shall hit; secondly, that it shall hit hard enough to penetrate or disorganise the enemy. The first requisite has formed the subject of my proposal, and I need not again insist on the necessity for accuracy of fire at even considerable distances. As to the second, I said, in a previous part of my paper, that Sir W. Armstrong's and Sir Joseph Whitworth's undertakeings to penetrate respectively 20 and 24 inches of backed armour, will probably be far exceeded by an equal authority.

I allude again to Mr. Bessemer, who was kind enough to explain to me, a few days ago, the results to which his long study of this question had brought him.

He is prepared to produce the following gun:—Bore, 30 inches; rifled, throwing a solid shot, at low initial velocity, weighing 5 tons, burning the whole charge of powder (about 400 lbs.) by a series of explosions automatically ignited successively at regular intervals between the first moving of the shot from the breech and its escape from the muzzle, so that, although the aggregate power will not be lessened, but rather increased by perfect combustion, the total concussion will be distributed both as to time and locality instead of being, as at present, concentrated destructively to the gun. This gun will load itself. It will also fire itself, automatically, at the rate of one shot per minute, as I have already mentioned, at the moment when

correctly directed at the enemy. If the Woolwich 35-ton gun, throwing a shot of 700 lbs., threatens to put an end to armour-plating, what will be the result of our possessing, and of course of other nations also possessing, guns discharging with accuracy, at long ranges, projectiles of 16 times the weight, in the presence of which the Woolwich "infant," in boastful irony so named, dwindles to a baby plaything in reality.

Time will not permit me further to pursue, to their legitimate consequences, the effects which improved accuracy, combined with increased power in Naval ordnance, must entail on Naval architecture, on Naval tactics, and on Naval training and education. My belief, stated in general terms, is that the conditions of Naval warfare will approximate in the future more nearly than at present to those of land warfare. That in the former, as long ago came to pass in the latter, defensive armour, being utterly ineffectual to give protection against improved missiles, will be abandoned as a costly and useless incumbrance; and that supremacy at sea, as on land, will belong to that nation which commands the most numerous sea battalions, the most powerful arms, the highest maritime qualities, the most perfect organization, and the most scientific tactical knowledge.

For some time past, the course which Naval construction has been taking has been, in one respect, in direct violation of this analogy. We have been concentrating our maritime forces in single ships to an extent that seems full of danger. A great iron-clad represents at sea a division of troops on land; a break down of her engines may disable her, and place her at the mercy of the enemy; one blow from guns such as are now promised us, might send her to the bottom. What would be thought of military arrangements such that a single shot might annihilate a whole corps d'armée? That we should have some large ships may, perhaps, always be advisable; but that we should, as we now do, place our chief dependence on them, is, in the highest degree, imprudent. We cannot have them in sufficient numbers to enable us to afford sacrificing them; and a judicious sacrifice of part of the forces is of the very essence of war. What seems to be required is, a very large development of the gun boat element for coast defence and attack, and a sufficient number of ships no larger than is required for great speed, for sea-going purposes, both armed with the heaviest ordnance. Hitherto the usefulness of gun-boats seems to have been greatly limited by the inaccuracy of fire incident to their inconvenient liveliness. The cure of this evil, by means such as I have now proposed, will render such vessels most formidable antagonists, of which large numbers may be economically maintained. It is difficult to conceive that any iron-clad now known could hold her own long against a score or two of such assailants, which, although some would be soon destroyed, would keep an incessant hail of well-directed 5-ton shot on her sides, exposed to the perpendicular fire of at least some of the attacking swarm.

In order to guard against misapprehensions, I would here recapitulate the terms of my present proposal. I do *not* advise that the present Navy of England should at once be broken up and sold for old iron.

I do not even advise that any existing man-of-war should be subjected to immediate alteration. I recommend nothing sweeping or revolutionary. I simply suggest that certain contrivances by a celebrated mechanical inventor should be subjected to examination and trial, in order that it may be ascertained whether their employment will, or will not, give marked preponderance to the attack at sea, the weak point of which at present consists in the unavoidable inaccuracy of fire caused by the ship's motion. If these modern contrivances are found to remedy this weakness, and the consequence should be, as I feel sure it will, great diminution of our dependence on armour, I feel certain that all persons not directly interested in maintaining the present system will hail the change with joy, as a relief from doubt and anxiety, no less than from an almost ruinous expenditure.

I wish, in conclusion, to express the hope that, whilst endeavouring to point out a way of escape from the oppression of armour-plating, I shall not be thought ungenerously to condemn those who have created that magnificent defensive system. It is not possible to think of that system without also thinking of its principal creator, Mr. Reed; nor would it be just to speak upon it without alluding to him.

I would briefly say that I yield him most heartily the highest credit for his immense services to the country and to the science of Naval architecture. It is impossible to tell what may not have been the political effect of his exertions to keep England ahead of the world in Naval defensive power; whilst his contributions to the art of shipbuilding constitute a well-marked epoch in the progress of knowledge, the value and importance of which will still remain, though armour-clads shall become things of the past. If a change should be shown to be necessary, I fully expect that Mr. Reed will be one of the first to admit it, and one of the foremost and ablest in indicating the best modes of effecting it.

Mr. Bessemer: Colonel Strange has not gone at all into the details of the mode of suspension, I believe purposely, because those may be arranged in different ways. Any platform that supports a heavy gun must necessarily move with a certain amount of friction. There is a vis-inertiæ in the movement of those large masses involved, which in all cases will absorb a certain amount of power. There are few modes of mechanically employing the necessary power for that purpose that would not impose upon the person directing it, so much manual exertion as to prevent his having the full command of it. There is, I believe, only one way in which that can be thoroughly effected, namely, by the use of hydraulic power. Water under pressure, as you are perfectly aware, may be passed through a valve and act with a considerable amount of power without the valve through which it passes, requiring much force to put it in action: hence it becomes a very ready means of transmitting power, particularly when that power is very uncertain in the amount that is to be administered, or the quantity or the distance it has to move. In contrivances of this kind, what is called an equilibrium-valve is generally used, but the ordinary construction of the equilibrium-valve has this immense disadvantage, that as the valve rises from its seat, the pressure exerts itself upon the sides of the cone, and a new and enlarged area of action results, and consequently the valve supposed to be in equilibrium is no longer so. In order to make my apparatus extremely sensitive and capable of being moved with a very small amount of force, I have adopted what I call a knife-edge equilibrium-valve, that is a circle with a raised rim, with a fine line only in contact. The result is, when it is raised, there is no new or additional surface for the water to act upon, because

we have an equilibrium valve by which a man can at once bring to bear a pressure of from 20 to 30 tons with a movement of a handle, which perhaps requires only 3 lbs. or 4 lbs. to move it in either direction. Consequently, with so very sensitive an implement as that, he has full command over the very heavy object it is intended to move. In placing a naval gun upon a platform it may be necessary or desirable that the floor surrounding it and its slides, and the whole paraphernalia of the gun in fact, should be retained in a continuous position, while all the surrounding parts rise or lower themselves by the rolling or pitching motion of the vessel; or the power may be applied in some cases certainly for a broadside gun, by employing this power only to move the gun on its trunnions if the ordinary screw for elevation be replaced by a small hydraulic cylinder, say 3 inches in diameter, and the gun has a preponderance say of 1 ton. Now a pressure of 400 lbs. per inch on a 3-inch ram, which presents a surface of 7 inches square, would give a pressure exceeding 1 ton on the ram, and would raise the breech of the gun, whereas the letting out of the water from under the ram would allow it to fall again. So small a quantity of water has to be dealt with in that case, and so small and easily moved a valve would be required, that the operator would be able to keep his gun constantly horizontal, notwithstanding any motion that the gun carriage was subjected to, or if a certain angle of elevation be desired, that also could be maintained, so that he would keep the gun always pointed on the object notwithstanding the rolling motion of the vessel. If the apparatus has to be applied to the whole platform on which the gun stands, a larger hydraulic cylinder and ram would be required, and it would not be quite so sensitive as the smaller one, but I think sufficiently so for all practical purposes. The mode of working guns at sea is a thing which I am very little indeed acquainted with, and I should not like to give an opinion before the very many practical men I see before me. They will be able to judge better than myself how far a steady platform will be valuable on board a ship of war. That such a platform can be rendered steady under every motion of the ship I have no doubt, certainly within an extreme range of one degree of movement whatever the movement of the ship may be. I do not know that there is any other point I need touch upon, with the exception of mentioning that at a future period I should have great pleasure in laying before the members of this Institution a description of the instrument which Colonel Strange was kind enough to refer to, as also providing a means of accomplishing this desirable object, that is, of directing a gun at sea. With reference to another allusion made by the Lecturer this evening to the large guns, I can well feel that the mere mention of such a huge implement without knowing the particular means by which such a thing could possibly be practicable, must appear a sort of Baron Munchausen story to those used to the small implement we now use. But you know that in every department of the arts, almost, we have heard from time to time of these gigantic strides. It is not so many years ago since the forging of a piece of iron was done by a certain number of smiths with 40-lb. hammers, and if a dozen were required, that number were employed on a single mass of iron, as in forging an anchor. Now if somebody had told us at that time that Mr. Krupp, of Essen, proposed to use a hammer weighing 50 tons, and to strike 60 blows with it per minute, it would have appeared very preposterous, but you know that the use of a 50-ton hammer is now an every day occurrence. I feel, however, that I come before you with respect to these enormous guns very much in the position of a person who might have told you that Mr. Krupp proposed to have a 50-ton hammer when only the 40-lb. sledge hammer was known. I shall have great pleasure in giving you my views on that particular subject on a more opportune occasion. (Colonel STRANGE: May I ask Mr. Bessemer to say if I have correctly described these proposed guns?) Quite so. (The CHAIRMAN: Do we understand that Mr. Bessemer is prepared to exhibit to us the instrument which the man is to observe whilst he is manipulating the valves, because that is the most difficult point of all?) Yes, it is a very small thing; I can bring it here without difficulty. My other models are rather too large.

Commander W. DAWSON, R.N.: The title of the paper is "Proposed Method of Mounting Heavy Ordnance at Sea on the principle of the Bessemer Saloon;" but it has embraced every subject connected with the sea. It was quite unnecessary for Col. Strange to offer an apology to naval men that he, as a military officer, should come

forward on the subject of naval gunnery. Naval gunnery is the child of the army; we owe the existence of the science of naval gunnery to a distinguished soldier. To this day we have no means of educating and training naval Officers in scientific naval gunnery, though we are to have a Professor of Field Fortification at the New College at Greenwich; so that we are at this moment as much indebted to the Army for our artillery ideas as when Sir Howard Douglas took us up, 40 or 50 years ago. We are indebted to soldiers, not only for building and supplying naval guns and naval gun-carriages, but for all subsequent inspection and repair of heavy ordnance. Though the Navy is not deemed worthy of a voice in these matters, and the training in our gunnery ships does not include intellectual culture in artillery science, yet it has a good deal of rough experience in the handling of heavy ordnance. Experience without knowledge may do for an operative gunner, but such problems as Colonel Strange brings before us, call for artillery education such as the Navy is deficient in. At the same time I think a more intimate acquaintance with the practice of naval gunnery would lead Colonel Strange to modify to some extent the idea that the inaccuracy of fire is entirely or even chiefly due to the motion of the ship. There is no question on the point that shooting at sea has gone back since the introduction of rifled ordnance; that seamen cannot shoot so well now as they could in the days of the old smooth-bore; but I do not think that is caused entirely by any accession of motion in modern ironclads. On the contrary, it is because we do not realise that the change in the gun necessitates a change in the mode of using it. We require now to know the exact distance to a few yards. This knowledge of the range is all the more necessary, as our rifled ordnance, having "decidedly the lowest velocities," have necessarily the highest trajectory, and therefore make the worst shooting at unknown distances. We also require to sight our guns on some sensible system, extending the distance between the fore and rear sights to the very utmost extent. When we pay attention to these two essential points, they will be found to account for a great deal of the bad shooting in ordinary weather. The third essential, that of giving us a steadier platform, which Colonel Strange has brought before us now, is very important. At the same time we should recognise thoroughly what are the limits of the inaccuracy which is caused by an unstable platform. Of course all seamen will agree that when a ship is rolling 30° each way, hitting the object is "a miracle," as was well put by a late Admiral in command of the Channel Squadron; but I am not quite sure that seamen think 4° or 5° roll a bad thing. It is the regularity of the roll, if it be only 4° or 5°, which is of most importance. Given a very regular motion, and I am not sure that seamen do not rather like 4° or 5° roll. There is another point we must keep clearly in view, and one which I would commend to Mr. Bessemer's attention when he speaks of regulating the rolling motion by movements of the breech. That might act very fairly when pointing right abeam, but obviously when the gun is being trained a little way before or abaft the beam, the contrivance would be inaccurate; and it must be remembered that in naval gunnery the gun is always being trained to right or left to the last moment of firing. The mere pumping up and down of the breach of the gun would not therefore meet the conditions of the case, even if the gun could otherwise be aimed by its captain. As to the moveable platform, all naval gunners will acknowledge to a great gain, by the reduction of motion to a certain small limit; nay, that it would be an immense gain, if Mr. Bessemer could do that which I understand he is sanguine enough to expect to do, namely, put the gun on such a platform that the gunners would not know whether the platform was on shore or at sea. Given as immoveable a platform as a battery on shore, and there is no naval gunner who would not immediately acknowledge that he could shoot very much better. But will he give us an absolutely motionless platform? It would of course be rash for me to offer a decided opinion on the absence of all motion at the moment when Mr. Bessemer is going to try the experiment at sea with his own saloon. My own opinion at present is, however, that absolute immobility will not be realised; that is to say, that Mr. Bessemer will not realise immobility so perfectly that the platform will be as steady as though the gun were on land. (Col. STRANGE: An extreme range of one degree.) One degree is 500 yards of range. (Col. STRANGE: One degree of arc.) One degree of vertical arc is 500 yards of range in the gun. The question is, will the gunner who is captain of the gun be able to make better shooting when he has to consider the proceedings of another gunner who

is introducing an uncertain human motion, independent of the natural movements of the sea, for there will be this irregular motion of one degree going on intermittently. This artificial movement of the platform depends upon the will of a human being, who imparts an accidental motion, which the gunner who is firing the gun cannot possibly anticipate. When a well-designed ship has a steady roll of 5° or 6°, there is a certain equableness in the motion that an experienced gunner can anticipate and allow for, taking his aim accordingly. But if there be introduced, instead of that equable movement, an irregular motion depending upon the will of another individual, I question very much whether what is gained by the reduction of the arc will result in more accuracy than the 4° or 5° of steady uniform roll. That is not, perhaps, the chief objection that I myself should raise to the contrivance. Until we have some indication of the apparatus and machinery, it is very difficult to form an idea of the structural difficulties which the naval architect will have to contend with, and therefore as to what it would cost, not in money, but in space and weight. One of the most pressing naval subjects is the re-armament of the present fleet rather than the building of a new one. It is not at all creditable or right that any one of our ironclads should meet any hostile ship and not be able to pound her, simply because the guns carried are too weak to perforate the armoured side of the enemy. We want, therefore, a re-armament of the fleet, so that every ironclad, whatever the thickness of her own armour, should carry guns capable of perforating the armour of any hostile vessel she came across—guns which have not "decidedly the lowest velocities," nor "decidedly the least penetrating power." Will the Bessemer apparatus for suspending gun-platforms be so heavy and occupy so much space that it will militate against the embarkation of heavier guns in existing ships? These and the structural difficulties are practical questions that should be determined before forming an opinion as to the cost of the contrivance in extra weight, space, and architectural devices.* Whilst ready to acknowledge that increased accuracy would ensue from greater stability of platform, which did not vitiate uniformity of roll, I am not quite sure that the amount of gain to the art of shooting would be very great if an irregular motion, dependent on the will of another man, were substituted; and if the gain to the marksman is not very great, then the question is governed by considerations of weight, of loss of space, and of architectural difficulties. If the artillerist gains little from the Bessemer gun-platform, what does the architect lose by it? These are practical questions which we ought to keep in sight, and I venture to recall Colonel Strange's attention to a letter which appeared in the *Times*, in answer to himself, signed "P. H. C." It was one of the best replies I have seen in that correspondence, and the initials are those of a distinguished naval gunner, whose name would have added weight to his opinions. "P. H. C." pointed out what were the real difficulties of artillery fire at sea; and also the fallacy of contrasting the action of many small vessels with that of one large ship, in a naval combat. The ideas put forward in that letter quite correspond with my own, and I commend them again to the Lecturer's attention.

Capt. SELWYN, R.N.: I desire to say a few words on this question. I am quite sure my friend Colonel Strange came here honestly to ask an opinion, and that he would be most dissatisfied if the discussion was not a full one. With regard to the question he has placed before us of a stable gun platform at sea, there is first to be recollected that those are in error who assume that a ship's motion can be recorded in two planes. This is entirely inaccurate. The ship has six different motions: first, rolling; second, pitching; third, rising on the uplifting wave; fourth, falling; fifth, swaying to the starboard; and sixth, swaying to port. No ship, even our best steering ships, of which we do not rejoice in many to-day, ever did move through the water with her head constantly on one point of the compass. These introduce a most complex set of geometrical curves. You cannot compensate by any possibility for these movements by considering them as acting through only two planes; and I

* If the gun-platform be anything like the diagram of the Bessemer saloon, exhibited at the Society of Arts, 5th February, 1873, the architectural difficulties, to enable the gun to point at an external object from a rolling ship, would be immense. —W.D.

think that this is a difficulty which should be thoroughly estimated. However it may seem not to have its value in the moderate seas commonly seen in crossing the channel, it is certain to have its value whenever you get into the deep long swell of the Atlantic, where we must come to decide our naval battles sooner or later, if we are ever to decide them. Next I draw attention to another difficulty which appears also to have its value and weight. I should be very loath indeed to fancy for a single instant that a gentleman whose magic touch has turned all our iron into steel would be unable to cope with any mechanical difficulty, but there are physical difficulties which only those who live on the ocean can appreciate thoroughly, and seamen are therefore bound to state them. In a ship in which you establish a stable platform for guns, in some portion of her you have to choose between two difficulties, you must either have that stable platform on the upper deck, with the sight from it entirely uninterrupted by surrounding objects, and therefore devoid of armour or any such contrivance; or you must have it below the broadside, armoured or not, as you please, but still having a hole through which the gun must point. If we adopt simply the platform *per se*, we have no great difficulty to leeward so long as the platform is on the upper deck; we have very great difficulty to windward, because the instant we attempt to point a gun in that direction the muzzle of the gun dips below the weather bulwark as the platform keeps its horizontality during the lee lurch, and you could not fire at all without firing through your own ship. Below, a similar case occurs. You must either unduly extend the vertical height above and depth below, of your port, in order to enable the sight to be obtained if the gun itself is on a moving platform, or in the case where the trunnions are the axis of rotation, you must also, though in a lesser degree, provide for the vertical elongation of the port. Under these circumstances, not only will the objections occur, which Captain Dawson has stated, but there will be the further objection that the gunner's eye must be moved to follow the breech of the gun rising and falling, which is most inconvenient, he must be alternately stooping down exceedingly low and rising excessively high, he is in no fixed position, and that position which he has to assume is dependent on the will of another person. These are all difficulties in the way of those things being properly carried out. I do not anticipate any great difficulty, knowing the use of the Rev. Mr. Berthon's log, by which the pressure due to velocity near the bottom of a vessel is recorded as the rate of speed in the cabin by an apparatus for the purpose. There is no practical difficulty in getting a level with water in tubes covered with oil in any vessel, provided the distance apart of the tubes be sufficiently great. But there is a very great difficulty, and one which I do not think we shall easily overcome, if all these contrivances are to be applied to a cupola. I assume we are still to have some armour if the platform is on the upper deck, because I confess I cannot see my way to fighting any action whatever with any sized guns in modern days without some description of armour. I am sorry to say even ironclads are not exempt from the liability to be set on fire. We do know the use of molten iron. I have fired a great many red hot shot myself, and I know what effects they have. I know also that modern projectiles are of such a destructive character that practically an absolutely undefended gun is an unworkable and unfightable one; no man can stand by it under modern fire. If even the large guns failed of their effect, the accuracy of small arms is quite sufficient to make it impossible to work them within such distance as I hope Britons will always seek at sea. I am not one of those who believe in shooting mosquitoes five miles off, or even ironclad ships. The problematical effect of the shot, which has been already adverted to as being extremely great on account of inaccuracy of fire, is more than doubled or trebled, it is centupled in uncertainty the instant you do not know whether your shot has missed or hit, which you never do at the very long ranges; you hope it has done something, and that is all. I am not one of those who believe that actions can ever be decided in that way. With regard to the question of stability of platform as derived from the form of the ship, I say the late Mr. Elder unmistakeably showed in this theatre that there was no difficulty whatever in obtaining a perfectly stable platform at sea—except as to the inclination of the wave, which we shall never overcome—as stable as a raft; that with that he combined a ship of the very greatest speed, the very greatest capacity, capable of carrying armour 6 feet thick if you like, if any such thing were desirable at all. You have only to increase the width of your

ship and you may increase the thickness of the armour without great increase of weight, because it only occurs at the edge of the ship, so to speak. Add to that Major Moncrieff's mode of carrying the guns below, and you have a ship which you cannot very easily attack, except by that modern enemy of seamen, the torpedo. There I confess, as far as I have been able to form any judgment myself, we are utterly and totally at a loss. If the torpedo should be guided with anything like the skill which has been shown in guiding all other weapons, these and all other floating vessels are attackable in a way against which they have at present no defence whatever. Cellular bottoms and everything else disappear at a touch when the torpedo explodes fairly under you. With Mr. Bessemer's platform I should say there is no difficulty whatever in doing some things for some persons, that is to say, I have no doubt whatever he will keep his platforms horizontal on board the vessels to which he proposes now to apply them. I am quite sure he is perfectly capable of doing that. Whether those who, I am sorry to say, get sick at the very sight of the sea will thereby be enabled to withstand the influences of the Channel, I do not know. I believe there are some stomachs so sensitive that not even the assurance that they are on shore secures them from sea sickness, but it will be a very great advantage to those who really suffer not from imagination, but facts, and I hope he will succeed in carrying it into effect. We shall derive very much instruction from seeing what he does in that way. Until then I think we may suspend our judgment as to what can be done at sea for gun platforms. With regard to the question of armoured *versus* unarmoured ships, I have in this and in other theatres constantly advocated the gunboat as opposed to the big basket in which you put all your eggs. I have said, over and over again, that the proper utilization of the naval reserve is in gunboats owned almost, so to speak, by the ports from which they proceed and to which the seamen belong. I believe that these will constitute the the truest defence of our coast. As regards doing away with armour for them, I am afraid they cannot carry any armour, but there is a safety in insignificance, and as long as you make your gunboat as small as she ought to be to carry the gun and do nothing else, not trying to make her a sort of hybrid cruiser at sea—a hybrid carrier of men to distant climes, where they roast in such a vessel in the torrid zone and freeze in the frigid—as long as you will be content to do one thing at a time, and not make a hundred bladed knife in which no one of the many blades can be used satisfactorily, you will get an object not easy to hit, and therefore not requiring armour so much, and you will get a thoroughly good gunboat for the defence of your coast. You may then turn your attention, if you will, to an unarmoured cruiser, to carry our flag over the world. In war I do not think such cruisers would be of any importance. I am sorry to say a change in our navigation laws has rendered it extremely doubtful whether the day after war is declared with the most insignificant nation of the earth by England, a single merchant vessel would remain under our flag to be protected. The insurance offices in the City take no note whatever of anything else but money risk, and the day they tell the merchants of England "we shall charge so much more insurance as "war risk on your vessel as long as she sails under the English flag," that day, by the result of the new navigation laws, commerce deserts your flag, as it did the American, and unfortunately it seldom returns when war has ceased. Wise legislation can do a great deal that neither soldiers nor sailors are able to effect. If that wise legislation is wanting, it is in vain to ask us to fill gaps with the sword which have been made by the pen. Still less can we hope to recover a naval prestige once lost, while other nations are pressing around us every day seeking to snatch from us all that we hold. It is not now a time for us to say all that we think about the efficacy of armoured ships. We hope to see wiser councils prevail. We hope to see careful experiments made before millions are wasted; but investigation alone can determine this, and such investigation ought not, as the Lecturer has so well remarked, be made a political rather than a scientific question.

Colonel STRANGE: I need make but very few remarks in reply to the observations which Captain Dawson and Captain Selwyn have been kind enough to make upon my paper. I am very glad indeed that Mr. Bessemer has made a few remarks, as they have given us a great deal of instruction. Captain Dawson laid great stress upon, what is no doubt the fact, that the gunner of the future, perched upon a Bessemer platform, will not be able to use the same devices as the gunner of the

present. I said that myself in my paper. This contrivance certainly should not be tested by attempting to combine with it existing methods. I went so far in my paper as to say, that I think it would probably lead, if it were introduced, to something of a revolution in naval gunnery; therefore I quite concur in Captain Dawson's objection that there would be a difficulty to overcome. But Captain Dawson very candidly admitted that although naval gunners at present find it convenient to have a little roll, they probably would shoot better still if there were no roll at all. I think he admitted that. Well now, the fact that they do so much enjoy this little roll is—I say it with all respect—in consequence of the defect of existing arrangements. They fire well in spite of the roll, not because of the roll. I cannot for one moment admit that they fire even as well as they do, because the ship rolls. Be pleased to follow me logically. If they fire well because the ship rolls, then we are driven to some curious consequences. Captain Dawson reminded me of a letter that appeared in the *Times* under the initials of "P. H. C.," in which the very same view he has expressed was taken, and although Captain Dawson says that letter was written by a very distinguished naval Officer, I must still venture to say I do not quite follow his reasoning. The stability of a gun's platform must either be desirable or undesirable. I cannot see how it can be both, and I hardly can conceive how it can be neither. It must be desirable or undesirable. If desirable, let us press that view of the matter to its legitimate consequences. The Royal Artillery should make their gun carriages roll. And, to go a little further, and apply the same principle to a different matter—astronomy is only another kind of gunnery—a kind of cruising—surely if this rolling is beneficial, the best thing for the Astronomer Royal to do would be to put his big telescopes on rockers, and work them with a donkey-engine. The doctrine seems to me, if pressed fairly to its legitimate consequences, to lead to conclusions which are almost an absurdity. But there is truth in what Captain Dawson says, that much depends upon the kind of roll; but that was not the view of the matter taken by the writer of the letter in the *Times*, who simply advocated motion. What Captain Dawson says has, I think, some weight, that the platform will not be absolutely motionless. Mr. Bessemer considers he can obtain horizontality varying only in the extreme, one degree. When you talk of the extreme variation being one degree, you mean of course that the average, the general variation, will be a good deal less; you are not always at extremes. Therefore we may suppose that, if Mr. Bessemer succeeds in doing what he thinks he can do, the gunner will have the advantage of a platform varying in its angular movements considerably less than one degree. Now that approaches, for practical purposes, so nearly to absolute stability, that for my part I feel inclined to take it as absolute stability. Whether that can be done or not of course I do not pretend to say positively of my own knowledge; I merely know that a gentleman who has devoted a great deal of attention to the subject thinks it can, and you will notice throughout my paper that I do not say positively that these things will be done, but what I positively do say is, that we ought to know whether they can be done or not, if the doing of them will lead to any advantage. Now I think Captain Dawson himself admits that if practical stability of platform is attainable, there will be great advantage, but you have still to prove that it is attainable—you have still to prove that you will thereby very greatly increase the accuracy of fire, and that in attaining this great increase of accuracy, you do not sacrifice some essential matter. Captain Selwyn and Captain Dawson, as practical seamen, have pointed out that there may be inconveniences—that the internal arrangements of the ship and so on may be disturbed by this contrivance; those are points to be brought out only by trial: the question is, is it worth trying? That is the immediate question I wish to raise in my paper. I am not aware that there is any further remark by Captain Dawson that requires reply. Captain Selwyn has adverted to a great many subjects, and the first was the subject of the six different motions. I took down the motions from his lips as he enumerated them, and they are really four: "rolling, pitching, rising, falling, and throwing her head about." Now rising and falling are the same (Captain SELWYN dissented); just as pitching is compounded of two angular motions; a ship in pitching rises and falls, but still you call those two motions pitching; and so rising and falling are the same kind of motion. I do not mean to say when a man jumps on a table that is the same thing as when he jumps under

the table, but he exerts himself in the same plane. Therefore, rising and falling are, speaking mathematically, one motion. Then, "throwing her head about;" now that is a lateral motion. I maintain that suspension in two perpendicular planes will preserve the horizontality of the body so suspended under all conditions. Here (showing a binnacle compass) we have a body so suspended. There is the rolling. I think Captain Selwyn admits that that motion can be counteracted by the suspension, and there is the pitching. Now how are either of those suspensions vitiated by any raising and lowering the box? (Captain SELWYN: We are speaking of pointing guns at external objects.) Certainly. We will come to that. The horizontality I maintain is the same, though the body rises and falls; but this up and down motion of which so much has been said, which is supposed to disturb the stomach, as we all fancy it does, is a motion that has yet not been fully investigated. I think common sense will tell you that its amount must vary with the size of the waves and the size of the ship. For instance, if you stand in a dock where there is a slight ripple, and watch bits of straw and cork and so on floating about, you will see the cork at one moment on the top of the ripple, and at another moment at the bottom, rising and falling the total height of the wave or ripple. But a great merchantman lying there would be absolutely motionless, the motion of the water, though acting very perceptibly on the cork, would be quite insufficient to make her rise and fall at all: therefore it is evident that that motion is dependent on the size of the wave as related to the size of the ship, and the larger the ship, other things being equal, the smaller will be the motion. I have not met with anybody yet who has determined the amount of this motion, and I shall be very glad if Captain Selwyn can tell me if a measure of that motion has ever been made. I am inclined to think not. I am inclined to think it has been so difficult to eliminate the other motions with which it may be confounded, that no measure has ever been obtained of that particular motion, namely, the motion of vertical translation. I still maintain that with the gun mounted in the ordinary way, you are subject to angular deviation, whilst with the gun mounted in Mr. Bessemer's way, you are subject to linear differences, and they are totally different. Therefore, I dismiss the rise and fall, because they amount to a quantity that is small compared with what you may expect from any kind of gunnery at sea at present. As for the side motion, that would have no influence upon the horizontality, which is the main point. Then Captain Selwyn spoke of the impossibility of firing guns to windward on account of the obstruction of the ship's side. Of course it would not do for a man to shoot through his own ship, but I was not alluding to guns shooting athwart ships. (Captain SELWYN: Just the same.) I deal in my paper with end-on fire. A gun in the bow has nothing to fear from the sides of the ship: it is clear of all obstructions. I advocate this contrivance of Mr. Bessemer's as peculiarly adapted to bow guns. I have said so in my paper, and of course with a bow gun you are not exposed to any obstruction whatever. If it is necessary to use the gun athwart ships, then either the ship must be made to suit those conditions, or you must wait till the roll takes place, and you can clear the side, or not shoot at all. Then Captain Selwyn said it would be very inconvenient for the gunner who might be supposed to be on the fixed part of the ship to rise and stoop to take aim, but I am supposing a state of things where people have not got to take aim. The gun fires itself if necessary, and dispenses altogether with aiming. I have particularly stated in my paper that Mr. Bessemer has a contrivance, which he has been kind enough to show me, and I think I have not incorrectly said that contrivance will enable the gun to fire itself, when it arrives at the inclination due to the distance of the object fired at. (Captain SELWYN: Are we to understand when the object is changed or merely when it is horizontal?) When it is horizontal. Of course this contrivance is not endowed with optical powers, but something very near it. Captain Selwyn has referred to Mr. Elder, of whose communication I did not know, who he says has solved the question of stability of platform as derived from the external form of the ship. I have before me an official document drawn up by some of the most distinguished seamen, engineers, and mathematicians of England, which goes to say that hitherto, that is up to 1871, those two things, namely steadiness of platform and stability or safety, had not been reconciled by means of external form. If they have since been, I am very glad indeed to hear it. Torpedoes, Captain Selwyn

admits, are irresistible, and I am very happy to hear from him,—for though we differ on some points, I have the greatest respect for his opinion as I have for himself,—that he is favourable to a great development of gunboats. Of course it is difficult to foresee what may be the result of new improvements, but it seems to me that this is the direction, that this contrivance is likely to be first employed in the perfecting of gunboats, and if it does that, it will have done a great deal. I have fallen foul of armour because I am not at all singular in feeling that armour has placed us in great difficulties; but unquestionably there were strong reasons for having recourse to it, and having recourse to it was quite justifiable at the time. But as we are advancing in knowledge and power, we have to revise arrangements which formerly were thought very judicious, and I think in the words of the report of the Committee on Naval Designs, and as I say in my paper, quoting the opinion of the most distinguished authorities composing that Committee, "the time is approaching when the superiority of the gun will be final and definitive."

The CHAIRMAN: If the discussion on the paper has been rather discursive, perhaps it is owing to the fact that the subject was so entirely new, and that the paper itself took a rather wide range. Colonel Strange perhaps, as a scientific man, has looked further forward than any of us were prepared to join him in looking forward, and we as practical men have been rather anxious for those postulates about which he spoke. Captain Dawson said, and many naval men will agree with him, that we rather prefer a slight roll at sea to having no roll at all. I think I may venture to add another explanation to that, viz., that what we like is, that when there is any roll at all, it should be a roll with a certain amount of amplitude rather than a short one; that what we do *not* like is, that the ship should take a slight inclination of about three degrees, then oscillate backwards and forwards over one degree; then take a roll in the opposite direction of three degrees, and oscillate backwards and forwards one degree. That is what we do *not* like, because we rarely cover our object; but what we *do* like is, that we should roll steadily and gradually through three or four degrees, so that we should be repeatedly covering our objects and having repeated opportunities of fire. Then again, I must say I think Colonel Strange has convinced us that the rolling and pitching are the only two movements which have to be made up for by such a platform. There is the movement of rising and falling, and the movement of translation. The movement of translation will very largely affect any instrument which has hitherto been constructed (except that of Professor Smythe) to guide the eye and judgment of the man whose hand guides the movement of the platform. Any instrument hitherto constructed, except that of Professor Smythe, will always partake of the inequality of the platform to the wave surface. Mr. Froude is going to read a paper on the subject shortly, so that I will not allude further to it.

I have now to ask you to return your thanks to Colonel Strange.

Evening Meeting.

Monday, April 7th, 1873.

REAR-ADMIRAL SIR ASTLEY COOPER KEY, K.C.B., F.R.S., in the Chair.

NAMES of MEMBERS who joined the Institution between the 7th and 21st April, 1873.

LIFE.

Littledale, H. W. A., Lieutenant, R.N.
Jocelyn, W. H., Lieutenant, R.N.

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Abbott, Saunders A., Major-General, late Bombay Army.
Bouverie, Henry H. P., Lieut. W.Som set Yeomanry Cavalry.
Barnett, Henry, Lieut.-Colonel, Oxford Yeomanry Cavalry.
McPherson, Cecil, Capt., 17th Regt.
Burr, C. E. G., Lieut., 17th Regiment.
Shepherd, Henry, Captain, 2nd Kent rtillery Volunteers.
Simpson, Frank, Staff Surgeon.
Todd, J. A., Lieutenant-Colonel, late 14th Hussars.
Macpherson, J. C., Captain, R.E.

APPARATUS FOR AUTOMATICALLY RECORDING THE ROLLING OF A SHIP IN A SEA-WAY, AND THE CONTEMPORANEOUS WAVE-SLOPES.

By WILLIAM FROUDE, Esq., M.A., F.R.S.

I PROPOSE to explain an automatic instrument I have made for recording some of the more important phenomena connected with the rolling of ships at sea. In order to explain the objects for which it is necessary that these phenomena should be recorded, it will be desirable that I should set forth in outline, some of the leading principles on which the rolling of ships depends. I would mention, however, at the outset, that the record given by the more special portion of this apparatus depends for its accuracy on simple mechanical principles, and is in no way dependent on the correctness of any theoretical assumption, yet its operation, as a whole, is specially relevant to the principles referred to, and its records will be specially suitable for testing the theory to which the principles seem to point. I need scarcely observe that the determination of the causes of the rolling of ships is an important and essential step towards the discovery of remedies for the evil.

In considering the rolling of ships, the primary question is, why does the passage of a wave cause the ship to roll? In what precise manner does the peculiar deformation of the surface of water called a wave, impress rolling motion upon a ship?

To consider, in detail, the various actions of each portion of the wave-

water, would involve complication; but these all resolve themselves into a total which is very simply expressed by the proposition that the ship tries to place itself upright to the slope of the wave, for the same reason and with the same energy as she tries to place herself upright to the level surface of smooth water. This may at first sight seem a little paradoxical; but it sounds more reasonable when it is suggested that the ship desires to place herself in this sloping position on the slope of a wave, in obedience to substantially the same set of conditions as those which cause the water itself to assume this sloping position. In fact it correctly expresses the effect of waves on bodies floating upon them, to say, that the apparent direction of the force of gravity, is square to the surface of the wave. This apparent alteration of the vertical direction of gravity, which causes the water to stand temporarily sloping instead of level, and causes bodies floating on its surface to try to become perpendicular to this slope instead of truly vertical, is due to the translatory sideways accelerations involved in the motion of the particles of which the wave consists.

This effect may be illustrated by a plumb-line. If its point of attachment is stationary, the plumb-line will hang vertically, but if the attachment be accelerated sideways, the plumb-line will hang askew as long as the acceleration is continued, the direction of the suspending line indicating what I have termed the apparent direction of gravity at the plumb-bob. If, for the plumb-bob, a cup of water is substituted, it will be seen that the surface of the water in it will be always square to this apparent direction of gravity, and the slope thus impressed on the water, is closely analogous to the sloping surface of the wave. For just as the acceleration sideways of the particles of water in the cup, causes the surface of the water in the cup to be sloping, so the acceleration sideways of the particles of water forming a

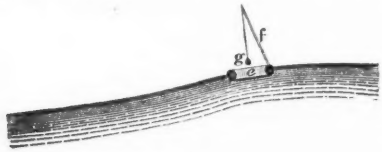
FIG 1.—EXPERIMENT OF FLOAT IN SUSPENDED CUP.

a. Point of suspension being accelerated sideways from left to right.
b. Suspending lines.
c. Cup.
d. Surface of water in cup perpendicular to the line of suspension, or the apparent direction of gravity.
e. Float in the water.
f. Short mast in the float carrying
g. A small plumb-bob which hangs in conformity with the apparent direction of gravity, and thus at right angles to the surface of the water.

wave, causes the surface of the wave to be sloping. And the analogy may be carried further, by placing on the water in the cup, a float having a small mast from which a plumb-bob hangs; then when the cup is swung about as before, not only does the water in the cup stand perpendicular to the line of suspension, but the float continues upright to the surface of the water, as also does the plumb-line hanging within it (see Fig. 1). In trying this experiment it is essential that the float should be very stable and the plumb-bob one of "short period," so that they should instantaneously assume the varying inclinations impressed on them by the varying external forces we are examining.

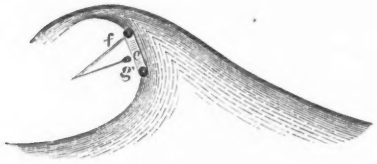
This proposition that the apparent direction of gravity is square to the surface of the water, which thus simply and directly describes the origin of the rocking forces administered to a ship by the waves, is shown by the above experiment to be true of the water in the suspended vessel. That it also holds good in the case of a body floating on waves is demonstrable by theory, and I have also shown it by an experiment with the float and plumb-line. In this case the float consisted of a cork ring like a life-buoy, about four inches in diameter, and was placed among waves of various form (see Fig. 2). In one case I placed it in waves breaking on a beach, and I could see it on, or rather under, the overhanging crest of a breaking wave, and even in this case the plumb-line was pointing rigorously square to the surface of the water, although that surface was actually facing downwards (see Fig. 3).

FIG. 2.—EXPERIMENT OF FLOAT IN WAVES.



e. Float made of a cork ring.
f. Short mast in the float carrying.
g. A small plumb-bob which hangs in conformity with the apparent direction of gravity, and thus at right angles to the surface of the water.

FIG. 3.—EXPERIMENT OF FLOAT IN BREAKING WAVE.



e. Float made of a cork ring.
f. Short mast in the float, carrying
g. A small plumb-bob which hangs in conformity with the apparent direction of gravity, and thus at right angles to the surface of the water.

The condition of things, then, under which it happens that a ship is set in rolling motion, and from which she derives that motion, when floating in wave-disturbed water, as contrasted with that under which she remains at rest in undisturbed water, is the fact, that, whereas in still water, the attitude into which the pressure of the water perpetually tends to force her, is constant and unchanging, in wave-water, on the contrary, this altitude is continually varying. It is in the constantly defeated attempt to attain the attitude of rest, that the ship among waves is perpetually changing her attitude; and since this attitude is

the ship's position of momentary equilibrium, that is to say, her right position for the moment; and since it is the fact that when she deviates from it by a given amount, the force which urges her towards it, is the same as that which tends to right her, when similarly inclined in still water, it may be conveniently termed a righting force, and I shall speak of it thus, even though it may be occasionally urging the ship into an inclined position, as it must do when she is more upright than if at right angles to the wave slope.

Were the ship perfectly rapid in her movements, if, that is to say, she possessed an infinitely powerful righting force when inclined in still water, or were her moment of inertia (that is to say her momentum as a fly-wheel) infinitely reduced, she would then at once attain this attitude of rest, not by being stationary, but by keeping pace precisely with the changing inclinations of the wave slope. But inasmuch as the force which urges her is necessarily finite, and her moment of inertia necessarily considerable, she is always involved in adventitious and additional movements, sometimes overrunning, sometimes falling short of the position she is seeking; and thus instead of following the motions of the waves like a raft, or, like the experimental floats, the ship "rolls."

The principle, then, out of which the rolling motion is developed, is profoundly simple; it is certain that it exists and must operate. It is what Herschel has called a "vera causa." Whether its operation is sufficient to account for and explain the rolling which a given ship will undergo when exposed to a given wave—whether in fact it is only a collateral cause, not *the* cause of the rolling, is a question which can only be answered by counting up its proper effects by the known laws of dynamics, and comparing them with the results which actually ensue.

It will be said that out of the multitudinous and confused inclinations which the surface of the sea presents, it is impossible to evoke order and uniformity enough to render the case amenable to treatment by ordinary mathematical processes. And this is undoubtedly true to a considerable extent, though to a less extent than might be *primâ facie* supposed.

It is true that we cannot by any method, mathematical or other, predict, when a ship is despatched on a given voyage, precisely how much rolling she will experience, partly because we cannot predict what seas she will encounter; partly also because no doubt the seas she does encounter will be of such unknown irregularity, that we cannot hope to appreciate their absolute effects.

But this difficulty is at least a conclusive answer to those who, without having even a definite *locus standi* as a basis of thought, who, even discountenancing the existence of such a *locus standi*, are yet ready to advance definite and confident predictions about the behaviour of individual ships.

I do not advert to men of large and varied experience, who attempt cautiously to educe rules, by induction, from the facts which their experience has supplied to them. Yet even to them I would appeal not to rely in this case with too confident preference on conclusions which

experience, taken alone, and unguided by established laws, may seem to them to have justified.

For, confidence in conclusions which such experience induces men to form, is nowhere so ill-placed as where the surroundings of the question are multitudinous and complex; since in such cases it is almost impossible to select with certainty, by experience unenlightened by theory, which out of those surroundings is the real governing condition of the problem. And on this ground I invite even those whose experience may have least inclined them to agree with me, to join me in tracing from the *vera causa* which I have explained, the consequences which, with a very near approach to exactness, must follow from it, by applying to it the known laws of dynamics and the known laws of wave motion.

Our problem is this. Given the rate at which the wave on which the ship rests, broadside on, changes its inclination *in transitu*, and given the rate at which the ship will change her inclination when exposed to a righting or inclining force of given magnitude, what will be the rate of change and the total amount of motion which will ensue as wave after wave passes under her?

In the first place, the laws which govern the motion of regularly formed waves, are now very well known, and are reducible into tractable mathematical expressions.

The rate, in terms of time, at which the slope of a wave *in transitu* varies, is almost exactly the same as that at which the inclination of an ordinary pendulum varies—quite nearly enough to be used in the investigation of this problem.

The rate, in terms of time, at which the ship will change her position, also admits of being exactly calculated, given her form and the disposition of her weights on the one hand, and the actual force on the other.

This branch of the problem, however, is perhaps best elucidated by tracing the actions on which it depends as exhibited by a ship when set oscillating in still water.

Let us suppose the ship to be hove down artificially to the successive inclinations, ${}_1\theta$ ${}_2\theta$ ${}_3\theta$, &c., by means of a succession of inclining forces acting on a lever of given length, and that the successive forces employed are ${}_1$F ${}_2$F ${}_3$F, &c. Now if on a base line we mark off a series of spaces which, dating from the same zero point, represent to scale the successive inclinations, and plant at the end of each, an ordinate which represents to scale the corresponding force, the tops of the ordinates, in effect, constitute a line which is called the "curve of stability."

This curve represents in fact the variation of the righting or inclining force in terms of the inclination, and it inevitably follows from the principles on which the stability depends, that up to some considerable inclination the righting force is exactly proportioned to the inclination, and for the purposes of the present explanation it will be assumed that this law holds good up to any inclination that the ship can in fact reach. The assumption involves so little error under ordinary circumstances, that the results deduced by help of it may be regarded as typical.

Such then is the force which, in still water, tends to right a ship

when she is forcibly inclined. It has here been viewed as a simple fact determined by an experiment performed on the ship herself; but it may also be arrived at by calculations based on the ship's form and the distribution of her weights, and may be expressed in terms of the elementary conditions inherent in the ship's form and displacement, namely, her weight, and her metacentric height, that is to say, the distance between her metacentric and her centre of gravity.* We have next to see what are the rotational motions which this rotational force will impose on the ship under the various conditions under which it is free to operate, excluding for the present the collateral action of what is commonly termed "the resistance of the water," and we will consider these motions first, as they are exhibited and measured by the ship's behaviour in still water.

When the ship after having been hove down, as described in still water, is released and thus allowed to right herself, the rate at which she will do so is proportioned, directly, to the righting force at the instant, and inversely, to her moment of inertia, that is to say, her momentum regarding her as a fly-wheel; and she will proceed thus with accelerated speed till she reaches the upright position (which she will pass through with a maximum velocity), and travel onwards with retarded speed till she reaches an inclination opposite to that from which she departed, and indeed equal to it but for the surface-friction, keel-resistance, &c., she has encountered *in transitu*, and which for the present, as has been said, it will be convenient to treat as non-existent. Thus she will continue to oscillate like a frictionless pendulum.

The time expended in the complete transit will clearly be the greater for a given total arc traversed, in proportion as the force employed is weaker, and the moment of inertia is greater. But if we compare the times expended in the transit by a given ship, according as the arcs are large or small, the condition that the righting force is directly proportioned to the inclination, shows at once that the time will be the same whether the arc is large or small, because in traversing the larger arc, both the acceleration and the accumulated velocity will be greater exactly in proportion as the space to be traversed is greater.

This is in fact the essential condition of isochronism in oscillation, and in virtue of this it happens that with a given ship, as with an ordinary pendulum of given length, the time occupied in performing a given complete oscillation or single swing, is within practical limits the same, whether the arc of oscillation be large or small. It is here convenient to observe that the time occupied by a double oscillation is called the "period," because it virtually completes the circuit, bringing the oscillating body back to the position and conditions from which it took its departure; and the "period" is perhaps to be regarded as the fundamental or standard unit of designation in most investigations allied to this; but as the half-period, or time of a single swing, appears to

* This is commonly formulated as follows:—$F = WM.\theta$, where F is the force, supposed to act with an unit of leverage, W the ship's weight, M her metacentric height, and θ the inclination.

me a more convenient unit in this particular investigation, I adopt it in preference, calling it the "time of oscillation."

It is easy to see that the rate of acceleration at any instant under a given righting force is completely expressible for a given ship in terms of her half period or "time of oscillation." And it is convenient to express it thus, because the time of oscillation is, *per se*, simply determinable by oscillating the ship in still water; though it must be added, that like the righting forces in still water, it may also be arrived at by the somewhat lengthy and laborious calculations* necessary for determining her curve of stability, and her moment of inertia, from the distribution of her weights.

Thus, then, as by inclining the ship forcibly in still water we may measure absolutely the force which at any given inclination urges her towards the upright position, we may by observing her time of oscillation when allowed to oscillate in still water, learn exactly at what rate she will acquire rotational velocity in any direction in terms of the rotational force which at the instant urges her in that direction; and we may proceed to import these considerations into the study of her behaviour when acted on by waves. I will again observe that the operation of resistance is still excluded from the enquiry.

Now in virtue of principles which have been already explained, the ship having for an instant a given inclination relative to the wave slope, will experience the same righting force tending to destroy that inclination, as she experiences when in still water she has the same inclination absolutely, or with reference to the horizon. And hence the rate and the direction of the acceleration which she experiences will be the same in both cases, in terms of the inclination to which it is due; and as the inclination relatively to the wave slope is the difference between the ship's absolute inclination and the slope of the wave, we are able to express the acceleration† at each instant, in very simple

* Assuming the moment of inertia and metacentric height to have been determined by the calculations referred to, then calling the time of oscillation T, the radius of gyration ρ, the metacentric height, as before, M, and the force of gravity, g, the formula for T is $T = \frac{\pi\rho}{\sqrt{g\mathrm{M}}}$; but T may have been simply determined by the still water experiment, as described, and this result is *per se* available.

In any case, by the laws of isochronous oscillation, the equation of angular acceleration in still water is $-\frac{d^2\theta}{dt^2} = \frac{\pi^2}{T^2}\theta$, θ being the inclination at the instant. The negative sign of the differential corresponds with the circumstance that the acceleration is always tending to diminish θ.

† The equation of angular acceleration for the ship broadside to the waves is thus $-\frac{d^2\theta}{dt^2} = \frac{\pi^2}{T^2}(\theta - \theta')$, θ' being the inclination of the wave slope at the instant. Now, the wave curve may, with close approximation to truth, be regarded as a curve of sines, if we take the height to be as small compared with its length as it usually is in large waves; and under these conditions, if Θ' be the inclination of the steepest part of the wave slope, and T the half period of the wave, it follows that approximately $\theta' = \Theta' \sin \frac{\pi t}{T}$, so that the complete equation is $-\frac{d^2\theta}{dt^2} = \frac{\pi^2}{T^2}\left(\theta - \Theta' \sin \frac{\pi t}{T}\right)$

The integration is somewhat lengthy, nor need it or its results be formally given here. The object of giving the fundamental equation is simply to show in complete

terms, since, as has been pointed out, the slope of the wave at each instant is easily expressible in terms of time.

The working out of the conditions tells us what will be the ship's inclination and angular velocity at any future instant, given the steepness of the waves and the ratio of their period to the period of the ship, and given her inclination, her angular velocity, and her position on the wave, at the instant from which the lapse of time is counted.

The simplest form to which the solution can be reduced, arises under the limiting conditions that at this point of departure the ship is stationary and upright, and is either at the crest or hollow of the wave when the slope is zero; and the results of this form of the solution will be taken as typical, and their principal features will be presently traced.

It is, however, instructive and perhaps necessary, to explain that if the solution is taken without any limiting conditions (namely, on the assumption that the ship when started at the zero point of wave-slope, possessed any assignable inclination and angular velocity), the completely general results that it presents are connected by a very simple and interesting relation with those obtained under the simpler form of solution. For, the ship's initial inclination and angular velocity at the level starting point may be regarded as, potentially, part of a definite oscillation, which, if continued independently in still water, would have assigned to her a definite inclination and angular velocity at every future instant. Now the interesting aspect of the general solution which I refer to is this: the prospective movements which it assigns to the ship are the same as we should arrive at by combining those which are potentially due at each instant to the equivalent still water oscillation, with those due to the operation of the wave series under the operation of the limiting conditions which give rise to the simple form of the solution. The total result at any future instant consists of that which the wave-slopes would have imposed on the ship independently of her initial inclination or velocity, added to that which the initial inclination and velocity would have imposed on her in still water or independently of any wave-slope, hence it is sufficient to regard the results of the simple form of the solution as typical.

The principal results arrived at are entirely common-sense in their character, and such as may be readily apprehended by any mind well trained in dynamical reasoning.

The most striking and the most important of them is the conclusion that when the waves which act on the ship, have the same period as the ship herself, the range of her oscillation will receive an increment of definite and constant magnitude, wave by wave, so that in the transit of a few waves she must be infallibly overset. I have myself produced this result by artificially generated waves of definite period, acting on a float so shaped as to oscillate with a minimum of resistance, and with the same period; it was invariably overset by the transit of four or

shape the circumstance that the whole mathematical theory of unresisted rolling can be worked out in reference to any individual ship on the basis of experiments which may be performed with her in still water. It will be seen farther on that the same mode of procedure is, with even greater appropriateness, available for the treatment of the difficulties which belong to the subject of resistance.

five waves. And this is what would, in fact, certainly happen to ships under the conditions named, if it were not that their oscillations are, in fact, performed in a resisting medium, and that their range is thus restricted by a growing force which will, in most cases, neutralise the increment before the fatal result ensues. But this branch of the subject has been, for the present, thrown out of the question, and will be noticed presently. At present it is enough to point out how thoroughly this conclusion, at least in its general form, accords with common experience, which tells us that if we wish to create the greatest amount of oscillation in a body capable of it, we must repeat the impulses, oscillation by oscillation, and in exact harmony with the phases of the motion. It will be in the experience of many Naval Officers especially, that even the largest ships may be worked up to an oscillation of very considerable range by running the crew from side to side, if only the runs are exactly timed to the recurring motion.*

The increment of range which, but for resistance, co-periodic waves would impose on the ship, wave slope by wave slope, or oscillation by oscillation, is $\frac{\pi}{2}$ (or about $1\frac{1}{2}$) times the inclination of the wave at its steepest part, so that on a wave, the steepest part of which has 6° of inclination, each oscillation would carry the ship 9° farther than its predecessor.

While this form of co-periodic oscillation is in progress, the ship's maximum inclination must always occur when she is at the top and bottom of the wave, and she is just at the middle of her swing when the mid-height of the wave passes her.

The result which is thus produced by co-periodic waves, is the most complete form of what is termed "cumulative rolling."

But cumulative rolling will also be produced by waves which are not co-periodic, though the amount of accumulation will be less, in proportion as the dissidence of the period or dis-periodicity (as it may be called) is great, since only part of each impulse can co-operate with the existing motion, and part must be antagonistic to it.

If the dis-periodicity is not very great, the transit of the first wave-slope will produce a result not far short of that which the first co-periodic wave would have produced; but, wave by wave, the want of harmony becomes more and more pronounced, the portion of the impulse which co-operates with the ship's roll becomes smaller, that which is antagonistic becomes larger, accumulation ceases and diminution commences, and thus the rolling, after attaining a maximum, dies out by just the same steps as those by which it had grown up.

Here again the results of the solution are strictly in accordance with common sense, and indeed with common experience.

A not uninteresting illustration of the action which has just been traced, is frequently furnished by the behaviour of a pocket-watch if divested of its chain and hung by its pendent on a nail, which often serves roughly as a knife-edge, and allows it to swing freely, as a

* This process is often adopted as a means of scouring a ship's bilges, a certain amount of water having been admitted to them that it may be thus forced to rush from side to side.

pendulum of very short period. In this condition, its period is generally not very far from that of the balance which is oscillating within it, and the alternate extensions and compressions of the balance-spring impress on it a series of alternating impulses of small but appreciable magnitude, and it will frequently be seen that the watch, regarded as a pendulum, will acquire a considerable series of oscillations, which, owing to the want of exact co-periodicity of impulse, grow up to a maximum, die out again, and recommence in an exactly reproduced order.

It is instructive to observe that the greatest increase of range which the transit of any single wave can, under any circumstances whatever, produce on the ship during a given roll, is when the phases of her rolling have become so related to those of the wave that the intervals of antagonism between the wave slope and the ship's motion, happen where the wave slope is near its minimum, that is to say, at or near the hollow and crest of the wave, the ship being inclined in such a direction that the approaching wave slope becomes piled up (so to say) on her inclination, and intensifies the righting force throughout the roll, the steepest part of the wave co-operating with the motion, and supplying an effective relative angle even when the absolute angle is near zero; and the relation which plainly best satisfies these conditions is that, whether the period of the ship be greater or less than that of the wave, the commencement and termination of the roll shall be about equidistant in point of time from the hollow and crest respectively. The whole effort of the individual wave is thus applied with its greatest possible advantage towards the augmentation of the roll, and does the least possible towards the alteration of the period.

There remains to be mentioned a third type of unresisted rolling, which, however, grows out of the solution only in its most general shape, by assigning to the ship an initial inclination and angular velocity which have a special relation to the ratio of the period and the steepness of the waves.

This is what is called constant rolling, and it consists of a state of things in which the operation of the successive waves obliges the ship to roll to an invariable range, her period being forced into agreement with that of the waves, though these are in fact dis-periodic.

This result, it will be seen, is in marked contrast to that type of cumulative rolling which has been traced out as deducible from the simpler form of solution when applied under these conditions, namely when a ship is engaged with dis-periodic waves. It is, however, one which may be even quantitatively arrived at without any technical mathematical reasoning, and it appears more instructive to trace it out thus than to refer to it merely as a consequence of the solution.

If we consider what is happening when a ship is oscillating at her natural period in still water, we must perceive that the period of the roll is determined by the circumstance that the righting force is throughout not merely in direct proportion to the inclination at the instant, but that the numerical term which expresses the proportion, is exactly of such magnitude as to bring out the result which does, in fact, arise, namely, such as will oblige the ship to complete the oscillation in that particular

time. But it is easy to see that if the proportion had been other than it is, whether greater or less, the speed of the ship's motion at each instant would have been increased or lessened accordingly, so that the oscillation would have been completed in a less or greater time; and a little reflection shows that the relation which subsists between the increase of force and the decrease of period, or *vice versâ*, is that the period will be inversely as the square root of the intensity of the force. It is as the square root of the intensity, not as the intensity simply, because, when the force is, for instance, increased, and the velocity thus increased also, the time during which the force acts is thereby proportionally lessened, so that, for instance, it requires a force of quadrupled intensity to produce in a given swing a doubled velocity, or a period twice as short.

Now a scale of force thus uniformly intensified throughout, or *vice versâ*, may by hypothesis be exactly supplied to the ship while oscillating in still water, if we suppose a wave of appropriate steepness and period to be (so to say) administered to her as she rolls, if the relation of its phases as it operates on her be duly related to the phases of her rolling. This relation must, in fact, be such that the wave-phase which makes the wave-force zero, namely, the transit of its hollow or crest, shall operate on the ship at the moment when she is upright and is moving with her maximum velocity, as happens with the force naturally delivered during the still-water oscillation; and further, that (again in accordance with that naturally delivered force) the maximum wave-slope or phase of maximum wave-force shall operate on her when she is at the extreme range of her oscillation: and so on, throughout. If these two conditions hold, it will be found that a due apportionment of uniformly increased or diminished force has been secured, corresponding with the alteration of the period.

If, for instance, we desire to assign the wave-condition under which the ship will perform an oscillation of given range, in half her natural period, when, as was just now explained, the actuating force must be throughout quadrupled, we may see that the necessary conditions will be fulfilled, if the wave we assume has in the first place half the period of the ship, and, in the second place, a maximum inclination treble the ship's maximum inclination; for this trebled inclination, combined with the ship's own inclination, supplies, in the whole, the quadrupled force. It will be readily seen that the general proposition which this instance has illustrated, must include the condition, that when the ship's period is thus to be shortened, the advancing wave slope must face in opposition to the ship's roll, so as to intensify the righting force. When it is to be lengthened the wave slope must face in accordance with the roll so as to moderate the righting force.*

* It is readily seen in the light of this reasoning, that the constant relation which must subsist between the wave-slope, the ship's inclination, and the period-ratio, is (retaining the previously used notation) $(\theta + \theta') = \frac{T^2}{T'^2}\theta$, or $\theta' = \left(1 - \frac{T^2}{T'^2}\right)\theta$. This of course includes the relation between the maximum wave-slope and the range of the ship's roll, which would be written $\Theta' = \left(1 - \frac{T^2}{T'^2}\right)\Theta$.

This arrangement thus worked out would keep the ship rolling to a constant inclination, and with a constant but modified period, for an indefinite time. This then is what has been called "constant rolling."

It is instructive to contrast the conditions under which the passing wave slope simply alters the period of the ship's roll, without either increasing or diminishing the range of the roll, with those under which it leaves the period of the roll unaltered, but produces the greatest augmentation in its range which, as a single wave, it is capable of producing. The characteristic feature of the contrast is that at the mid-height of the wave when the wave slope is steepest, in the former case the ship's angular motion is zero, and the full range is attained—in the latter the ship's angular motion is greatest and she is in the middle of the roll. Thus the whole effect of the wave in the former case is devoted to the alteration of the period; in the latter to the augmentation of the range.

It is now time to turn to the essential but (theoretically speaking) somewhat obscure subject of Resistance; that force or set of forces, namely, which is called into existence in the surrounding fluid by the ship's motion, always acting in opposition to her motion, and tending to bring her to a state of rest.

It is not proposed here to deal with the subject in its theoretical and obscure aspect, but rather to trace the action as measured by experimentally ascertainable results, and to explain how these may be used to correct, or rather to complete and reduce into a practical form the abstract propositions in which the laws of unresisted rolling have been expressed.

Here also the behaviour of a ship when set oscillating in still water throws much light on the operation of the force we are investigating.

If, when by running men from side to side, or by other means, we have set the ship rolling to a considerable range, we cease the impulse and leave her to carry on the oscillation without interference, we shall see that, roll by roll, the range of oscillation becomes extinguished, and after a time the ship will come absolutely to rest. This extinction is obviously both the consequence, and the natural exponent, of the resistance experienced by the individual ship.

Supposing that by exact observations both of time and range, or what is better, by automatic means, we have obtained a record of the *rate* of extinction, we have thus in effect secured a measure of resistance in a shape which directly serves our purpose.

For while in the former part of the investigation we learned how much motion the transit of a given wave will communicate to the ship during the performance of a given roll, we learn in the ascertained rate of extinction, how much motion the resistance acting during the performance of the roll, will abstract from her. It is true that the solution thus obtained must be regarded as only an approximate one, but its *rationale* is simple and intelligible, and plainly takes us very far in the right direction, and on the other hand, it is found that practically the results which follow from it are very near the truth. It is true also,

that we cannot readily initiate artificial rolling to as great an inclination as to include the deepest rolls which possible waves will impose on the ship; but within the limits of easy experiment we can attain sufficient range to determine with considerable exactness, the law which governs the rate of extinction in terms of the range of the roll, and are thus enabled to calculate it pretty exactly for much deeper rolls. In fact, if after having performed the experiment and recorded its results, we mark off, on a base line, successive equal intervals, representing the count or numeration of the rolls, and duly plant on the base thus marked, a series of ordinates representing, to scale, their successive ranges, the ends of the ordinates will constitute a curve, which is a portion of what may be termed the "curve of extinction," and which may be extended by calculation as proposed.*

Speaking broadly, we may say that just as the theory of unresisted rolling has informed us what is the roll-originating power exerted by the waves, roll by roll, so this curve tells us what is the roll-extinguishing power exerted by the resistance, roll by roll; and it is plain that accumulation must cease when the rolling has become so deep that the two forces, roll by roll, are equal. And clearly this state of things indicates that under the operation of resistance, a form of constant rolling tends to become established, resembling, but differing of course in some characteristic peculiarities, from that already described.

The simplest case in which the application of this principle can be traced is that of rolling in co-periodic waves.

* It appears to me, both by experiment and by a rational appreciation of the data, that the rate of extinction as governed by the range, is expressible by the sum of two terms, of which one is simply as the range, the other as the square of the range, so that, if in mathematical language we put Θ as the range of the roll, and n as the number or count of the roll (*e.g.*, first, second, third, &c.), the rate of extinction or *loss of range per roll* will be $-\frac{\Delta\Theta}{\Delta n}$, and we have $-\frac{\Delta\Theta}{\Delta n} = (a\Theta + b\Theta^2)$, and the expression, if regarded as the differential equation of the curve of extinction, is readily integrated; and on a careful analysis of the numerous specimens of these curves which I have treated, it has proved in every case that such values of (a) and (b) might be introduced into the integral of the equation, that the calculated curve will fit the experimentally determined curve with remarkable exactness. Hence it is presumable that it would be found to accord pretty nearly with what would have been the result of experiment, if this could have been extended so as to include rolls of as great range as are ever encountered.

It is also probable that the terms which thus accurately express the resistance in the case of still-water rolling, will bring out an approximately correct result when applied to rolling in a sea-way, for it is presumable that the resistance the ship will experience in performing a roll of given range will, in the aggregate, be approximately the same, whether it is performed in still water or in a sea-way.

Only when the conditions are such that the ship is forced to perform the roll in a lengthened or shortened period, a correction must be made in accordance with the effect which the difference in velocity will have had on the resistance. But the correction may be readily made in virtue of the condition which rationalises the separate existence of the two terms of the equation involving Θ and Θ^2, the condition, namely, that the resistance is made up of two elements which are respectively proportioned to the velocity and to the square of the velocity with which the roll is performed.

Here, as we have seen, the transit of each successive wave slope would, but for resistance, be capable of adding, roll by roll, an increment of range $\frac{\pi}{2}$ (say $1\frac{1}{2}$) times, the steepest part of the wave, whatever be the range already attained; and this may be termed the potential increment. The actual increment which takes place in each roll will, therefore, fall short of this, by a quantity which corresponds with the extinguishing effect of the resistance during the roll, and will become zero therefore, when the range is so great that the rate of extinction equals the potential increment appropriate to the particular wave series.

Now, on reference to the complete curve of extinction, it is easy to see what part of the curve exhibits, as due to a single roll, a decrement of ordinate equal to the potential increment, and the ordinate at the middle point of this portion of the curve indicates the maximum range of roll which the particular wave series can impose on the particular ship.

When this state of things has been arrived at, so that the ship will, wave by wave, perform an oscillation of definite magnitude, in which on the whole, the impulsive force of each wave slope is balanced by the resistance experienced during the corresponding roll, the state of things is somewhat analogous to that of a clock pendulum which is kept going by the "maintaining power." In both cases alike the aggregate "work" communicated by the impulse, equals that abstracted by resistance, only that in the case of the clock the impulse is momentary, and is administered solely at the middle point of the swing, while with the ship engaged in this particular type of rolling, the phases of the wave and of the roll are so related, that the impulse is delivered continuously, and *pari passu* with the resistance, indeed throughout in tolerably exact proportion to it, for, as has already been explained in relation to unresisted co-periodic rolling, the instants of maximum inclination of the ship, when her angular velocity is zero, are at the top and bottom of the wave when the slope is zero, and the instant of her maximum velocity is almost precisely when the mid-height of the wave passes her, and the wave-force is at its maximum; and as the resistance increases and decreases with the velocity, a general equilibrium is thus approximately maintained.

The analogy between the maintaining power which sustains the swing of the clock pendulum, and the wave impulse which maintains the ship's oscillation, supplies a point of view from which we may see our way to what is virtually the conclusion which has already been reached, but in a somewhat different, and in effect, a more comprehensive form; as an answer, namely, to the question, what must be the steepness of a wave series of given period to keep the ship rolling with a given range, instead of to the question, what will be the range of oscillation imposed on the ship by a wave series of given period and given steepness.

If we trace out the answer thus in relation first to a co-periodic series, we shall see our way to the solution in a more general form.

If we assume the ship to be set rolling up to a given range in still

water, then if the medium in which she rolls were incapable of offering resistance, the rolling would continue for ever without any abatement, just as would happen with a frictionless pendulum oscillating *in vacuo*. If we now suppose the resistance of the water to begin to operate, we may propose to ourselves the enquiry, what system of surface disturbance must we at the same time impose on the water, in order to neutralise the extinguishing power of the resistance, and maintain the rolling with unchanged period and with unabated range.

Clearly the disturbance must be of the nature of a co-periodic wave series passing under the ship, with its inclination so apportioned to the ship's angular velocity as to be assisting the ship's motion, just as the resistance obstructing it.

Were it possible to create a wave series, the steepness of which should follow an arbitrary order in terms of time, we might make this order such as precisely to neutralise the resistance at each instant; but in fact we are not at liberty to assign this order precisely, since when the steepness of the wave series has been defined at any one particular point, the order of its steepness at other points is defined by inherent dynamical laws; yet, as has been pointed out, these inherent laws do in fact so define it, as to correspond very nearly with the order in which the resistance is delivered, and if we assume a wave series of such mean steepness, that its impulsive effect will be in the aggregate equal to the aggregate extinguishing effect of the resistance, the range of the oscillation will be conserved; only the intermediate variations of the ship's inclination as she rolls, will experience some almost infinitesimal modifications of alternate accelerations and retardations, during the progress of each roll.

Now the curve of extinction tells us how much of the assumed range would be lost by resistance in the single roll of the assigned mean range; on the other hand, the laws of unresisted oscillation tell us that the transit of a single co-periodic wave slope of given maximum inclination is capable of adding to the range of the ship's previous roll an increment of range, which is a little over $1\frac{1}{2}$ times that inclination, or (shaping the proposition suitably for our present purpose) to add a given increment of range per roll by the intervention of a co-periodic wave, we must make the maximum wave slope barely $\frac{2}{3}$rds of that increment, which is in effect identical with the conclusion already reached.

But having now gained the idea of a wave series as a maintaining power, we can apply it to the case of what has been called "disperiodic" rolling, and by help of this idea we may proceed to determine what is the wave series which will keep the ship rolling with a forced period, either longer or shorter than her natural period, and with a range unimpaired by resistance.

In the first place, we have already seen how, in the theory of unresisted rolling, the introduction of an auxiliary wave series, with its steepness and its phases definitely related to those of the ship's oscillation, will maintain in the ship the definite range of oscillation, but with the period altered in any assigned degree.

It is true that the alteration of period involves an altered scale of

velocity in the performance of a given range, and, therefore, an altered scale of resistance; so that the data presented by the curve of extinction are not nakedly applicable; but, if we know the law of resistance in terms of velocity, we can deduce from the curve of extinction the extinguishing power of the resistance operating during any given roll, if performed by the ship, in either a lengthened or a shortened period; that is to say, if we know the obstructive "work" done by resistance during the roll of given range if performed in the ship's natural period, we can determine it when the same roll is performed in the altered period, and can also determine the corresponding new decrement of range.

Hence, proceeding by exactly the same method as before, we can define in terms of this newly determined decrement, the steepness of the auxiliary wave series which is required as a maintaining power to neutralise the effect of resistance operating under the altered period.

Thus, to maintain the rolling of given range in a dis-periodic wave series, the combined operation of two distinct auxiliary wave-series is required—one of which may be called the "period-governing" series, the other the "maintaining" series; but for reasons which have been already explained, the relation between the wave phases and those of the ship's oscillation, are characteristically different for the two auxiliary wave series.

The instant of the maximum wave slope in the "period-governing" series, concurs with that of the ship's maximum inclination and the zero of her angular motion; in the "maintaining" series, it concurs with the zero of her inclination and the maximum of her angular velocity.

The combination, or superposition as it is called, of these two auxiliary waves, creates the total wave by which the roll of given period and range will be maintained in the ship. Perhaps, however, those to whom the idea of a wave, consisting of several waves in superposition, is for the first time presented, may desire some explanation.

The figure or profile of a wave-series is represented with sufficient exactness by a continued repetition of what is called the "curve of sines," a curve the nature of which may be sufficiently described to those who are not conversant with it mathematically, as follows:—Imagine a clock pointer to travel once round the dial, while the wave passes from crest to crest, and let the length of the hand be half the height of the wave from hollow to crest, when drawn to the required scale; draw a horizontal diameter across the dial, and draw a base line, spacing it off with intervals representing either the length, or the period, of the wave from crest to crest, then subdivide each of these intervals into twelve equal spaces, corresponding with the time intervals at which the pointer arrives at the successive hour-marks on the dial, and at each station thus fixed on the base, draw an ordinate, the length of which is the vertical distance of the end of the pointer, above or below the diameter; the length of this ordinate represents the height or level of the wave surface at that instant.

The following well-known and interesting property of this kind of curve, illustrates what is called the superposition of waves:—

Draw any two such curves on the same base, making them alike only

in the length of base, and different to any extent in their vertical height, and in their respective starting points on the base. Then add, at each point on the base, the ordinate of the one curve to the ordinate of the other, observing only that when the one ordinate is on the opposite side of the base from the other, addition means subtraction. The combination constitutes a third curve, not only like in character to the other two, but actually a true curve of sines, differing from its constituents only in the diameter of the imaginary circle from which it is constructed, and in the position of its starting point on the base.

The geometrical property thus traced out, explains at once the geometrical result of the combination of the two auxiliary wave curves, and the conservation of the dynamical operations which the waves were calculated to supply separately; for the steepness or slope of the combined wave (just as happens with the ordinate representing its profile) is everywhere the sum of the slopes of the constituent waves, and it thus correctly performs, in the lump, their separate duties.

The compound wave series is, in fact, the wave series which will keep the ship rolling with the given range; and if for a sufficiently extensive series of imagined ranges and periods of rolling, we deduce the elements of the appropriate compound waves, and tabulate the results, it is as easy to read the table backwards as forwards, and infer from the elements of the wave series, what is the range to which it would make the given ship roll.

It is necessary to point out that this tabulated range, is that which the ship would reach only after several consecutive waves had passed her. For when first acted on she would commence moving as if she had no power of resistance, and would thus more or less faintly conform to that type of unresisted rolling which belongs to dis-periodicity, and which involves the growth of the range to a maximum after several rolls, with subsequent diminutions in a recurring series; indeed if the ship possesses but slight power of resistance it is probable that the first, or even the second of the recurring maxima, will be slightly in excess of the final range as given in the table.

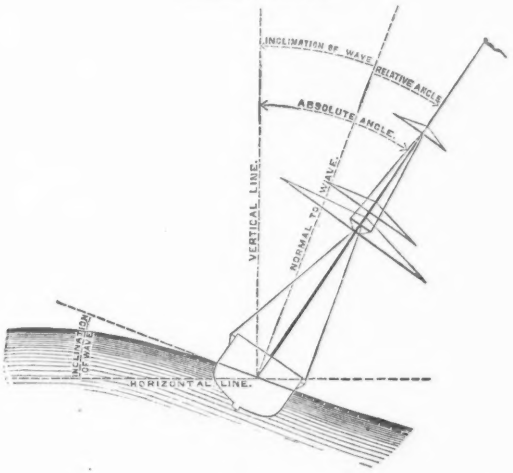
The excess cannot be large. Its actual amount can only be determined, so far as I know, by a process of "graphic integration," which it would occupy too much space to describe here. It may, however, be added that, speaking broadly, it remains true that in resisted as well as in unresisted rolling, the wave-series of given steepness which will impel a given ship to the greatest range of rolling, is that which has the same period as the ship herself.

Having now sketched the general principles that govern the rolling of ships, and traced their leading results, I will proceed to the consideration of the recording apparatus which it is the object of this lecture to explain. It is manifestly of great importance to have the power of verifying and of correcting the theoretical conclusions at which we have arrived. To do this we require the means of recording exactly the behaviour of any given ship under various conditions of the sea, and of recording at the same time what those conditions are.

This is done in the present apparatus, by keeping a continuous

record, first of the angle which at each instant of time the ship's mast makes with a truly vertical line; and, secondly, of the angle which at each instant of time the ship's mast makes with a line drawn normal, that is to say, at right angles to that portion of the wave-surface on which the ship is at the instant of time referred to. The first of these angles, namely the angle between the ship's mast and a truly vertical line, may be conveniently called the ship's *absolute angle*, and the second angle, or the angle between the ship's mast and the normal, may be called the ship's *relative angle*, as being taken relatively to the wave-surface (see Fig. 4). The *absolute angle* is the angle

FIG. 4.—EXPLANATION OF THE TERMS "ABSOLUTE ANGLE" AND "RELATIVE ANGLE."



usually referred to in all ordinary records of ships rolling; thus, when it is stated that a ship rolled 10 degrees to port, it means that her mast made an angle of 10 degrees on that side with a truly vertical line. It will be evident, however, from the principles set forth in considering the causes of the rolling of ships, that it is important not only to record the *absolute angles* of a ship's rolling, but also her angles *relatively* to the wave-surface, it being borne in mind that the righting tendency of the ship tends to place her mast at right angles to the wave-surface. It must also be remembered, that the apparent direction of gravity to a body floating on a wave, is at right angles to the wave-surface, as was indicated in the experiment of the short plumb-line on the float, either in the suspended cup or in the wave-water (see pp. 859, 860, and Figs. 1, 2, and 3).

A vessel may to all intents and purposes be considered to roll about her centre of gravity, and thus the centre of gravity while partaking

of the vertical and translatory motions imparted to the vessel by the waves, will be free from the rotatory motion experienced by the other parts of the vessel, and a pendulum hung freely at the centre of gravity of a ship will not be disturbed by the rolling of the ship, and will thus be under conditions similar to those of the plumb-line in the small experimental floats before referred to.

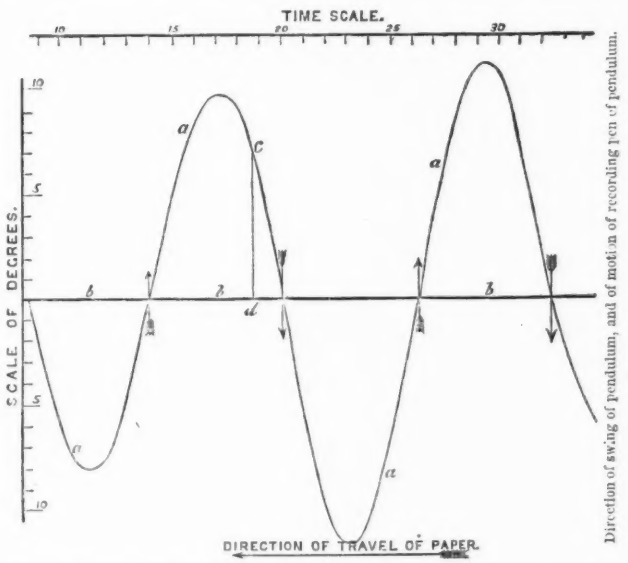
But for the reasons I have before pointed out, even a pendulum hung at the centre of gravity of the vessel in a seaway, will not, as on shore or in still water, hang constantly in a vertical line, but it will point in a direction at right angles to the wave-surface, so that its record is fallacious if taken to indicate the *absolute angle* of a ship's rolling. Still more misleading is the record of a clinometer placed at any part of a ship other than the centre of gravity, for then it will be subject to the rotatory motions of the vessel. The extent of the error thus introduced is exhibited by the larger inclinations assumed by lamps hung, even with much friction, under the upper deck of a lofty ship, or the extent to which in walking the upper deck of a vessel rolling, one must, in order to counteract its sideways sway, lean over to an angle far greater than the angle actually rolled by the ship. For instance, a pendulum-clinometer hung at the upper deck-level of an old line-of-battle ship would often swing to an angle at least half as much again as the true angle of the vessel's roll on the wave. Moreover, as the clinometers placed on board ships are of some length and freely suspended, they, when subject to the rotating movements of the vessel, set up a considerable swing of their own, and thus the record is still further vitiated. There can be no doubt that many most exaggerated statements as to the angles to which vessels have rolled, are due to the angles having been measured by the clinometer.

But though fallacious as a record of the *absolute angles* rolled by a ship, a pendulum gives a valuable record if hung at the centre of gravity of the ship. Here, as I have said, it will be free from adventitious influences, and will tend to point constantly in a direction at right angles to that portion of the surface of the wave on which the ship is for the movement. If, then, we can keep a continuous record of the positions which at each instant of time the pendulum assumes—assumes, that is to say, in relation to the mast of the ship, we shall have a record of the *relative angle*, that is to say the angle which the ship herself makes at each instant of time with the wave-surface. I will here point out that, as I have said, the tendency of the fluid pressures is to set the ship at right angles to the wave-surface, and as this tendency is measured in terms of the angle the ship makes with that wave-surface, it follows that the record given by the pendulum, forming, as I have said, a continuous record of the *relative angle* the ship makes with the wave-surface, supplies also a continuous record of the forces of the water acting on the vessel to cause it to rotate in the one direction or the other.

The way in which the successive positions of the pendulum are continuously recorded, will be familiar to most of my hearers, being similar to the self-recording operations of indicator diagrams, tide gauges, &c. As the pendulum swings in the ship, it moves a hori-

zontal rod, which works a pen to and fro over a sheet of paper, and this is made to travel at right angles to the swing of the pendulum, at an uniform speed beneath the pen, by passing over a cylinder which is made to revolve by clockwork. A wavy curve is thus traced on the paper (see Fig. 5.) To interpret the diagram, a base line or zero is

FIG. 5.—DIAGRAM LINE TRACED ON MOVING PAPER BY PEN ACTUATED BY PENDULUM.



a. Curvilinear line traced on moving paper by recording pen.
b. Zero line, or straight line, that would have been drawn by the pen had the ship's mast remained at right angles to the wave slope, and thus not deviated from the line of the pendulum or the apparent direction of gravity.

In this diagram, the ordinates of the curve, as *c d*, indicate, by the scale of degrees, the "relative angle," or the angle made by the ship's mast, with the normal to the wave surface at the instant of time represented in the diagram by the distance along the line *b* of the point *d*.

drawn along the paper intersecting the wavy line and occupying the position which the pen would have occupied had the ship remained at rest, with the pendulum hanging parallel to her mast. Lengths measured along this base by the time scale denote time, and if at any point in the base an ordinate be drawn to the wavy line, the length of the ordinate, measured by the scale of degrees, denotes what was the angle between the pendulum and the mast at the corresponding instant of time.

The pendulum in this apparatus is made very heavy, and has a very short period. In appearance it is very unlike what is usually understood by a pendulum. Instead of a long bar with a big weight

at the end of it, it is a horizontal heavy cylinder suspended by its upper edge (see Fig. 3, plate XLVIII*). Thus, while very heavy and powerful, the weight is very near the point of suspension, and consequently the time of each swing is very short. A pendulum like this, of short period, while it instantaneously obeys the forces impelling it to set itself at right angles to the wave surface, is much less liable than a longer pendulum to be influenced by any adventitious causes, and is less likely to set up, so to speak, a swing of its own. The pendulum is delicately hung on knife edges in a special manner, which I shall have occasion hereafter to refer to.

I have now, I think, explained how a pendulum, though misleading as a record of the *absolute angle* of rolling of a ship, may be usefully employed to furnish a continuous record of the relative angle, which, let me remind you, measures at each instant the righting force acting on the ship. Before leaving this branch of the subject, I should mention that this method of recording the relative angle had been successfully adopted by M. Bertin, an able French naval architect of Cherbourg, before it independently occurred to me.

I will now proceed to consider the methods for observing the absolute angle of a vessel's rolling, that is to say, the angle which her mast makes with the vertical. By far the readiest point of departure for this purpose, when it is available, is an observation of the horizon. To the uninitiated I may explain that an observer standing up in a ship sufficiently high to observe the horizon clear of the waves, sees the horizon apparently rise and fall up and down the rigging as the vessel rolls, and by using the spaces between the ratlines of the rigging as a scale, a very correct appreciation of the angles to which the ship rolls, may be obtained. To employ the same principle more exactly, a graduated staff or *batten* is fixed upright against the bulwark of the ship, with degrees of inclination marked on it. The observer, with his eye at a proper height and distance from the staff, notes the angles to which the ship's side is depressed and elevated in reference to the horizon, or, in other words, the *absolute angles* of rolling of the ship. But this observer cannot do more than note the extreme angle reached by the ship in each roll, or at most, with the aid of an assistant with a watch, he can note the extreme angle, and the time at which each roll is made.

It is, however, desirable to obtain a continuous record of the angle assumed by the ship at each instant of time, a record, in fact, analogous to that which I have already described as given by the pendulum. If we had in the ship a bar endowed with the property of remaining truly vertical, or indeed in any fixed position in a vertical plane, it is clear that this bar might, like the pendulum, be made to actuate a pen which pen should trace a line recording the angles which at each instant of time the ship makes with the fixed bar, or in other words with a truly vertical line. It is to supply this fixed bar that the special portion of the apparatus I have to describe has been designed.

In some of the experiments I have lately conducted on the rolling of ships at sea, the function of this fixed bar was supplied by a rod or

* The Institution is indebted to the Institution of Naval Architects for Plates XLVII and XLVIII.—Ed.

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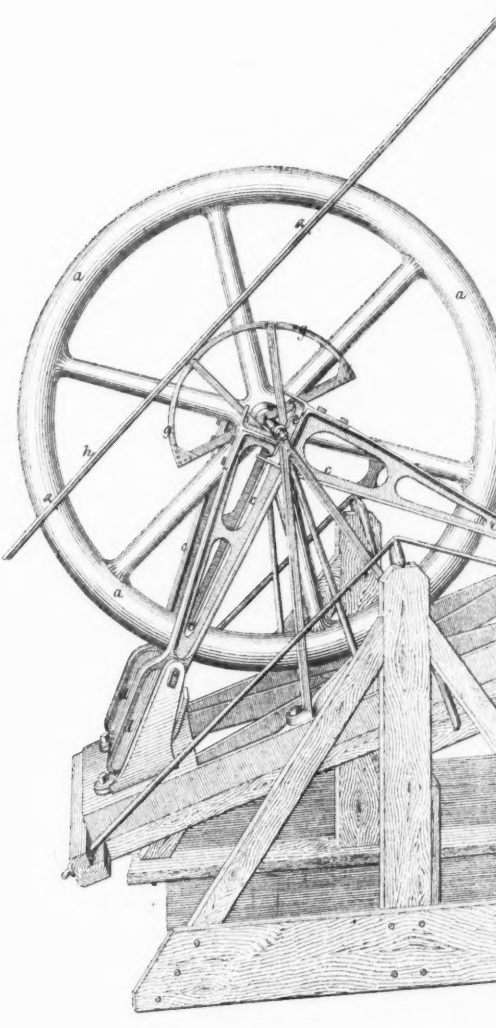
To illustrate Mr Froude's Paper on an Instrumen

From a photograph of the apparatus as mou

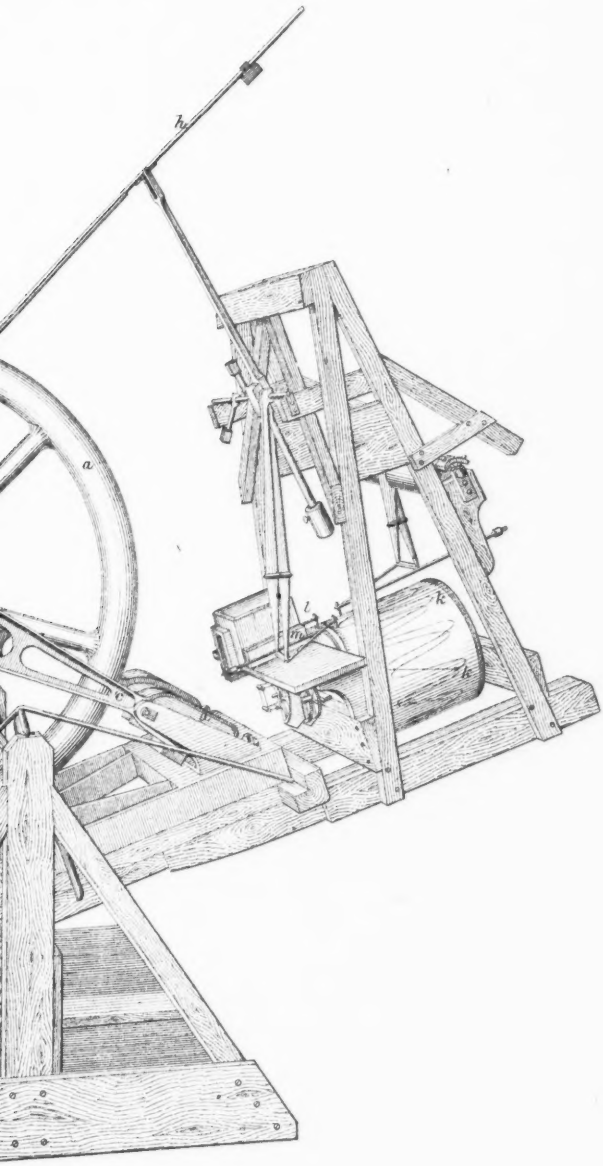
the deck of a Ship rolling in a seaway



Instrument for automatically recording the rolling of Ships.

aratus as mounted on a rocking platform representing

in a seaway, and for the instant greatly inclined.



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To illustrate M^r Froude's Paper on an Instrume

Fig.1. General arrange

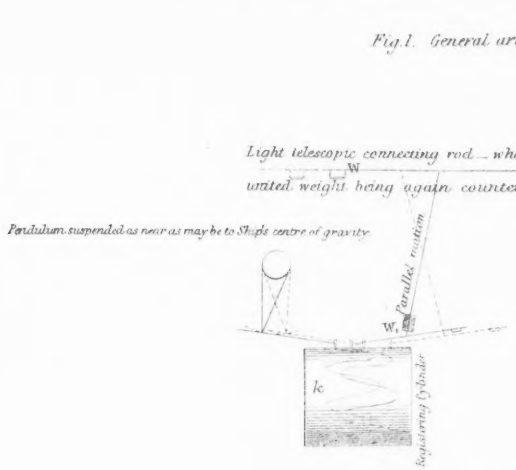


Fig.2. Mode of mounting frictionle

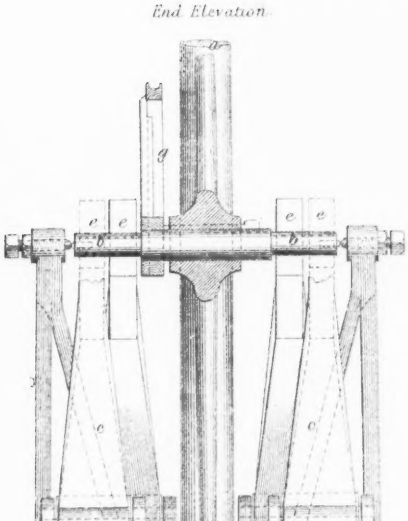
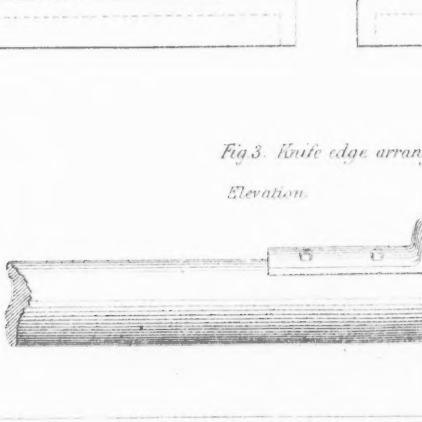
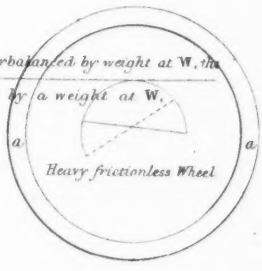


Fig.3. Knife edge arrangemen



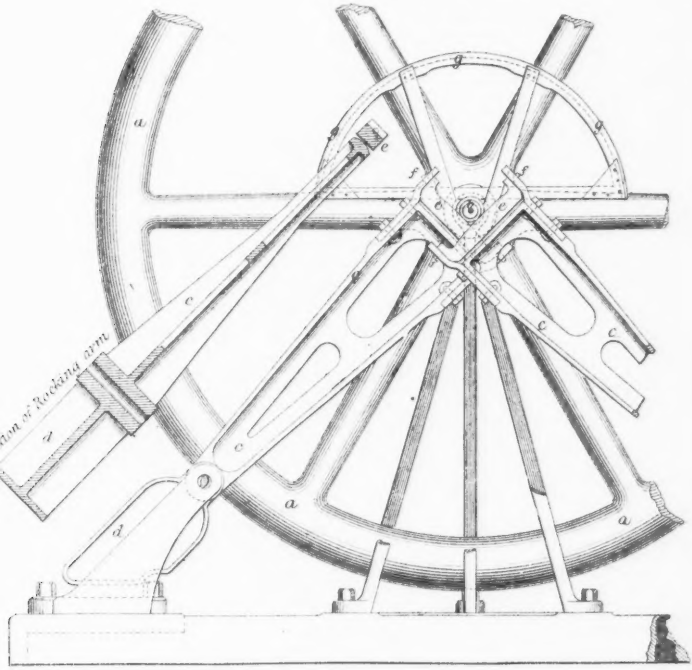
an Instrument for automatically recording the rolling of Ships.

ieneral arrangement of Apparatus.



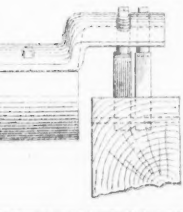
unting frictionless Wheel. Scale 1 inch = 1 foot.

Side Elevation.

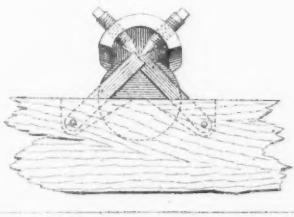


ge arrangement for suspending Pendulum.

Scale 2 inches = 1 foot.



End view.



pointer, which an observer on the upper deck of the vessel kept level by pointing it continually at the horizon. The motion relatively to the ship, of this really motionless pointer, was conveyed to its recording pen by strings led down through the deck. It is evident, however, that a method of this sort, depending on the skill of an observer, and which can be only employed in daylight, should, if possible, be replaced by some self-acting piece of mechanism.

Admiral Paris has suggested and applied the gyroscope for this purpose, but the difficulties of maintaining continuous rotation and of rendering the suspension of the gyroscope sufficiently free from friction, have proved too great for its useful adoption.

I have accomplished the result by paying due attention to the far simpler dynamical principle, that a mass of matter which is at rest will remain at rest, except so far as it is put in motion by external force, and thus if, while we push it about, the force by which we push it is such as will not communicate rotation, no rotation will ensue. Now, any mass of matter suspended by its centre of gravity is, theoretically, in this condition, and a balanced fly-wheel is in this condition if held only by the centre points on which it balances, assuming this suspension to be frictionless. If the wheel thus mounted were placed on the deck of a ship, the ship might be swayed about by the waves and might oscillate incessantly beneath the wheel without imparting to it any rotary motion. It would remain thus at rest, simply because there was no cause for its assuming rotation. But to utilise this method in practice, it is necessary to adopt some method of suspension most carefully freed from friction.

The use of a knife-edge suspension, such as that of a delicate scale-beam, would be a ready way of securing the result; but, unfortunately, a knife edge, to work with exactness, requires a level, or nearly level, plate to rest on, which could not exist in a rolling ship; while a notch deep enough to prevent the knife edge sliding sideways, under deep inclinations of the ship, would be fatal to its proper action. The well-known expedient of a cylindrical axle running on friction rollers, of course suggests itself as an alternative, and it is seen this may be simplified, when it is recollected that the angles through which the ship rolls are limited, and an absolute rotation of 60 degrees on either side of the position of rest is more than sufficient for all the duty that could legitimately have to be thrown on the axle, by the oscillation of the ship. Hence but a very small portion of the circumference of the friction rollers can be called into play, and it is thus sufficient to provide only a small segment of the circumference of the roller, instead of a complete wheel, and the radius may be thus greatly enlarged without introducing cumbrous dimensions in the apparatus as a whole. In fact, this arrangement has been successfully employed as a frictionless method of suspending clock pendulums.

Assuming that a heavy wheel may thus be provided with a practically frictionless suspension, there remains, however, the necessity of obliging the relative motion of the ship and the wheel, to produce a continuous record on a travelling sheet of paper, and it is obvious that this process can hardly be accomplished without the introduction of

some adventitious friction, involved in the process of marking the line, or in the motion of the parts which carry the marker. This adventitious friction, however, is of course independent of the weight of the wheel; and, by making this weight sufficiently large, the friction, per pound of weight of wheel, may be reduced so far as to be immaterial.

Thus far the wheel has been spoken of as absolutely balanced on the axis of support; but it is plain that under these circumstances the slightest motion, if once imparted to it by any accidental cause, such as a touch from the hand or even the clothes of the attendant, would continue without abatement, and that the wheel would ultimately overrun the range of the friction rollers, nor would it be possible for a bystander in the moving ship so to touch the wheel as to set it at rest in its proper position. This difficulty may be surmounted by giving the wheel a slight preponderance on one side, making its centre of gravity slightly eccentric—thus making it, in fact, a pendulum with a very long period of oscillation. It is true that it becomes thus subject to the disturbing causes which necessarily operate on a pendulum suspended in an oscillating ship. But if the preponderance is very small, and, consequently, the period of the pendulum is extremely long, the time during which a disturbing cause operates in one direction is relatively so short that the amount of disturbance actually created during its operation, may be rendered inappreciable, and will be obliterated during the counter oscillation. In fact, bearing in mind that, on the average, the sea is level and the ship is upright, the wheel with its slight preponderance, if set in motion, will simply oscillate very slowly, and will gradually come to rest in its proper mean position, the motion becoming gradually extinguished by the resistance of the air and other retarding causes. Having thus generally characterised the conditions which must be adhered to to give effect to the suggested method, I will point out how they have been carried into effect in the apparatus shown in Plates XLVII and XLVIII.

The wheel (*a*) weighs 200 pounds, and is 3 feet in diameter; it rests on an axle of steel, coated with hard steel collars (*b*), 1 inch in diameter. The centre of gravity is about ·006 of an inch out of the centre of the axle, and the time of a single swing from right to left is about 34 seconds. Each friction roller arm (*c*) has a radius of 18 inches, and consists of a stout casting, with a counterbalance (*d*) below its pivots; the segment-facings (*e*) are of hard steel, $1\frac{1}{4}$ inches broad. It will be seen that if these were rigidly fixed to the radii, the axle would almost inevitably take its bearing on one or other edge of each segment. To prevent this they are mounted on pivots (*f*), so as to square themselves into perfect contact with the axis. The delicacy of the suspension is attested in this particular instrument by the smallness of the rate of extinction of its own oscillation when put in motion, and by the fact that when at rest, a breath on the circumference will move it perceptibly.

The axis carries a wooden semi-circle (*g*) having a circumference $\frac{1}{8}$ inch to a degree, and by a connecting-rod (*h*), which takes the motion of the circumference lineally, the angles are transferred to and become marked on the travelling sheet of paper (*k*), tracing a continuous curve (similar to that already described as

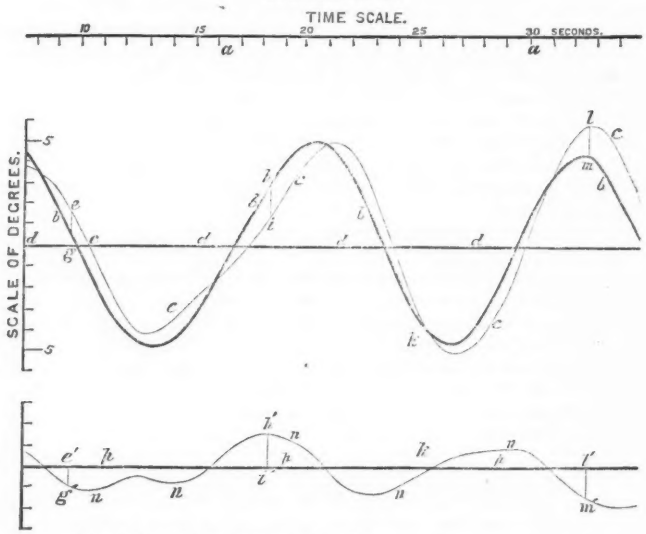
traced by the pendulum) the ordinates of which are the absolute inclinations of the ship at each instant, and the abscissæ the intervals of time. The motion of the paper is nearly isochronous. The paper, however, has a time scale marked on it by a piece of clockwork (l), as it travels. Each line is traced, not by a pencil—for this requires pressure to secure its marking—but by a pen consisting of a light vulcanite cylinder 0·1 of an inch in internal diameter, which delivers the ink through a conical metal point, having an aperture 0·005 of an inch; the pen and the arm that carries it (m) are counterbalanced, so that its point barely touches the paper, while the ink is delivered by its capillary adhesion to the paper. The friction is thus practically inappreciable. Should it happen, as it occasionally does, that the wheel is put into motion by some accidental external impulse, the oscillation thus instituted is performed with the long periodic motion which the wheel independently possesses, and thus it scarcely even disfigures the curve which shows the ship's oscillation. The result simply is that the curve is thus referred to a base-line of small definite curvature, instead of to one absolutely straight. The angles indicated by the pendulum, are similarly traced on the same paper and to the same scale.

Before leaving the subject of the details of the instrument, I should mention that I propose to make trial of a somewhat different arrangement for the frictionless support of the wheel. Although the arrangement as it stands at present, has answered very well, it requires great attention, as a very small speck of dust getting between the segments and the axis of the wheel, is sufficient to impede the free motion of the parts, and to set the wheel oscillating. I said before that a knife edge suspension for the wheel would not answer, as a knife edge to work properly must rest on a level, or nearly level plate, which could not, of course, be obtained in a ship, where, if the plate was tilted, the knife edge would slide off. However, after this instrument was made, it occurred to me that the difficulty of employing knife edges might be got over by placing, at each end of the axis, two knife edges at right angles to one another, with their edges in the same straight line, in prolongation of the centre line of the axis of the wheel, one knife edge being nearer to the wheel than the other, but both of them being rigidly connected with the wheel. These knife edges would rest on flat plates, which would be placed at right angles to one another. Thus the tendency of each knife edge to slide down over the inclined surface of the plate it was resting on would be prevented by the other knife edge pressing against its plate. To prevent any rubbing of the knife edges on the plates, and to allow for any errors of workmanship in fixing the knife edges in their exact position, the plates on which the knife edges rest, will be made so as to rock on short radius arms, in a similar manner to the segments on which the wheel axis now rests. Not only will this arrangement of knife edges be simpler and more compact than the present arrangement, but the small bearing surfaces of the knife edges will be able to crush and obliterate particles of dust, which would have done mischief between the circular axis and the segments. This arrangement of knife edges is adopted for the bearings of the

heavy short period pendulum already described, and is shown on Fig. 3, Plate XLVIII.

To return to the objects of the apparatus now before us, and having described the manner in which we obtain two curved lines drawn on paper which supply us with the information we require as to the *absolute angle* and the *relative angle* of the vessel's mast at each instant of time (see Fig. 6), I wish to point out that from these two records we

FIG. 6.—EXAMPLE OF DIAGRAM MADE BY INSTRUMENT, SHOWING RESULT OF ANALYSIS OF IT.



a. Time scale marked by clock on the paper as it travels.

b. Curvilinear line drawn by wheel, and indicating by its ordinates, to scale, the "absolute angle" of the ship at the instants of time indicated by the time scale.

c. Curvilinear line, drawn in like manner by pendulum, and indicating "relative angle" of ship at each instant of time.

d. Zero line to which the ordinates are referred.

n. Curvilinear line referred to a zero line, *p*, deduced from the curvilinear lines, *b* and *c*, by taking the differences, as *e g*, *h i*, *k l*, *l m*, between the ordinates of these two curves, *b* and *c*, for the ordinates *e' g'*, *h' i'*, *k'*, *l' m'*, of the line *n*. Thus the curvilinear line *n* represents by its ordinates the difference at each instant of time between the absolute angle and the relative angle; and this difference (see Fig. 4, page 875), is the wave slope.

NOTE.—In the actual diagrams as taken by the instrument, the lines *b* and *c* are not placed, as here shown, in their correct juxtaposition, since it is necessary in order to allow the pens to pass one another that they should work in different positions on the paper, hence before analysing the diagrams, one of the curves has to be "plotted" again in its correct position. Also, the curvilinear line drawn by the wheel has to be corrected for any curvature in its zero line due to long oscillations of the wheel. Both these corrections have been made in the diagram here shown, which is taken from an actual diagram produced by the apparatus.

can at once obtain a measure of the wave slope on which the ship is at each instant of time.

For this wave slope will clearly be the difference between the absolute angle and the relative angle (see Fig. 4, page 18), and so the angle

of the wave slope at each instant of time, is represented on the diagram by the distance between the two curved lines. Now by knowing the wave slope at each instant of time, we can graphically describe the form of the wave by plotting on paper successively the different inclinations of wave surface indicated by the diagram. But although we can thus draw the form of the wave, we do not know its actual dimensions. We have a correct drawing, but we do not know the scale on which it is drawn. We can determine this, however, in the following way: if the interval of time between the passage of two successive waves is known, the received theory of waves tells us what is the distance between the crests of those waves. Now a reference to the diagram tells us the interval of time between the passage of two of the wave crests we have drawn, and thus we can find the distance between the wave crests, and so we get the scale of the drawing of the wave.

Here then we have by the pendulum and wheel diagrams, a means of recording the waves which act on a vessel at sea. We have by the pendulum diagram, a record of the forces tending to make the vessel roll, and we have by the stationary wheel diagram a record of the extent to which the ship actually does roll. Thus a great help is given to our power of treating theoretically the rolling of ships, for we have the means of verifying our theory by practice, seeing in what way they differ, and determining the cause of that difference.

For instance, we have determined for a given ship, by rolling her in still water, her scale of resistance to rolling, and from this we are able to predict what will be her behaviour in any given waves. We try the same ship at sea, and from the diagrams we obtain a record of the waves she experienced. We then apply our information as to the still-water resistance, and calculate what, according to theory, should be the ship's behaviour, namely to what angle she should roll at each point of the waves in question. But we also have an exact record of what she actually did do in those very waves, and we thus have a crucial test of the accuracy of our calculations.

I may mention that in some experiments conducted for the Admiralty, this test has actually been applied in the case of two ships of over 1,000 tons, one of them having large bilge keels, and it appeared that the actual oscillations in the seaway went precisely through the phases which the theory prescribed; but as regards the amount of roll, the angles actually reached were throughout slightly less than those theoretically deduced, and this indicated that either the resistance experienced by the ships while rolling in the seaway was greater than that indicated by the still-water trials, or that the effective wave slope was throughout somewhat less than that indicated by the diagrams.

Also by the accurate records given by this instrument, we can determine the merits of different forms of ships so far as their qualities affect their rolling, for we can measure their behaviour under strictly comparable conditions. It is impossible to get the sea exactly alike on different days, and thus great differences of opinion exist as to the relative merits of various ships. But with this apparatus we can tell what were the conditions under which a vessel exhibited exceptional behaviour and in what respect those conditions or that behaviour differed from

those experienced or exhibited by the same or other ships at any other time. We are able thus to judge of the value of the various devices tending to modify the rolling; the effect of alterations of stowage of the additional of bilge keels, and of the steadying effect of canvas can be exactly recorded and measured. The direction in which to search for further remedies may thus be indicated, and important improvements may be confidently anticipated.

The CHAIRMAN: I do not know whether any one will venture to discuss this paper, but if any gentleman wishes to ask any question, or to have any further explanation, I have no doubt Mr. Froude will be very glad to afford it.

Captain COLOMB, R.N.: A *sotto voce* remark fell from the Chairman, that he thought nobody would dare to make any comments upon the paper, and I feel his difficulty, the condition of things being this, that whereas an audience in this theatre listening to a paper is usually in the position of a number of critics upon the performance of the reader of the paper; our position to-night is that of a number of disciples sitting at the feet of a master. I should think that nobody in the Navy, and I might possibly go further and say, nobody in Europe, would attempt to *criticise* such a paper as we have heard to-night,—most elaborate, and yet so clear, that even I suspect the thickest of our heads (and I number mine amongst them), have been able to follow it to a very great extent. I do not suppose that it is possible to offer that sort of criticism which Mr. Froude, in common with other great minds, would wish for. But what one would like to do would be to try to convey to a mind such as his, some of the difficulties that ordinary minds such as ours feel in following him. My difficulty, and I only mean to advert to one, is that purely elementary one upon which the theory of the wave rests. I understand, so far as I have read the papers on the now received theory of the formation of waves, that any particle on the surface of an advancing wave slope describes a circle in a direction opposite to that in which the wave is travelling; that it reaches the top of the circle at the moment the crest of the wave reaches it, and that, consequently, it finds itself just where it started when the wave has completely passed, supposing that it started from the bottom of the wave slope, and that the slope passed it, and then that it found itself at the bottom of the next hollow. Now my difficulty is to understand that translation of the wave particle. Waves we know are of very great height, and the diameter of the circle described by a particle on the surface of a wave may reach, I suppose, 30 feet. Now it is a difficulty to my mind to get the theoretical fact to coincide with one's personal observation. I have not myself, except in breaking waves, observed that particular translation. And there is one observation that I have made which increases the difficulty to my mind. When a perpendicular surface, such as the side of a breakwater, is offered to advancing waves, any small object lying within a foot or two of the perpendicular surface does not appear to an observer to alter its distance from it. Its motion appears to be distinctly vertical; as the wave rises, so the object rises; as it falls, so the object falls. But you cannot by that sort of observation detect a difference in the slope of the wave, nor is there in such a case any break or disturbance of the surface of the wave itself. It is of course quite different in a breaking wave, such as we see in a surf. There we have what is described a distinct motion of the particles which we can detect with our eye. We know that if you place a small object on a rolling surface, you observe that it has that motion of translation which I understand it is supposed that every particle of a wave has, even in deep water. We have that translation in a breaking wave very distinctly brought under our observation in every rolling sea. We are accustomed to note the commencement of the breaking of a wave, and after the wave has completely spent itself and broken, we can trace a long drift of foam where the breaking wave has passed over. That, Mr. Froude, is my difficulty. I hope you do not think I am a doubter. I am trying to be a learner, and no more, and I think if you can descend to our minds, I should just like to give one piece of confirmation to some points you have stated which are to those who have studied the question quite accepted, but I believe are not so accepted generally in the Navy; one is the isochronous vibration of ships. I made it my

business last time I was at sea, at any spare moment, whatever the state of the sea was, even in comparatively close harbours, to take that sort of rough observation which was possible, and I found in the ship I was in, no matter what the state of the sea was, in the heaviest sea and when the motion was hardly perceptible, the motion of the ship never seemed to be under 11 rolls, and never over 13.

Again, another point you adverted to was that cycle of rolling; that is how, in certain seas, you arrive at a maximum arc, and then that your roll became less and less down to a certain point, at which it began again to increase. I made observations upon that point, and I have tracings of the rolls, where I noticed that most distinctly; but I did not at that time know the cause, which has been explained to us to-night.

Dr. HIRST: Since the efficacy of the beautiful piece of mechanism which Mr. Froude has exhibited to us this evening, depends essentially upon the perpendicularity to the surface of the wave passing under the ship, of the direction indicated by the short pendulum of his apparatus, I should like to ask him to what extent this perpendicularity may be actually relied upon. The diagram on the right represents an extreme case, the circumstances of which might be roughly imitated by rigidly connecting the point of suspension of a short pendulum with the circumference of a large wheel, and on the concave side thereof. Now if the wheel rotated with sufficient velocity, centrifugal force would undoubtedly preponderate to such an extent as to maintain the perpendicularity of the string of the little pendulum to the immediately adjacent part of the circumference, which here represents the profile of the wave. But at smaller velocities of rotation, this would certainly not be the case, and the question arises whether some similar departure from perpendicularity may not present itself in the experiments of Mr. Froude.

Independently of the extreme case I have just alluded to, we have been informed by Mr. Froude that the shortness of the length of his pendulum is essential to the accuracy of the indications of his instrument. He has told us, moreover, that the centre of gravity of the large wheel, which turns on friction rollers, is slightly below the axis on which it turns; so that the wheel itself represents a slowly oscillating pendulum, in other words, a simple pendulum of great length; and the machine, unless I have misunderstood his description, may be said to record automatically the variations which occur in the inclination of these two pendulums when the wave is passing under the ship. Hence, if both pendulums alike placed themselves perpendicular to the wave surface, the instrument would obviously not serve the purpose for which it was designed. Its efficacy, therefore, may be said to depend materially upon the difference between the virtual length of the one pendulum, and the actual length of the other. I should be glad to know if Mr. Froude has had an opportunity of ascertaining the effect of altering the relative lengths of these pendulums. I have given frank utterance, Sir, to the thoughts which occurred to me as I listened to Mr. Froude's interesting paper. Those now present who, like myself, have not made such questions a subject of special study, may be glad to have the difficulties I have raised removed. To Mr. Froude this will be an easy task, for we all know with what experimental skill and large experience he has worked for a long time upon this and other kindred portions of a very important but difficult subject, a subject which up to the present time has remained, I believe, almost inaccessible to rigorous mathematical treatment.

Captain SELWYN, R.N.: Allow me to ask a question or two for my own instruction. Would Mr. Froude be kind enough to give us the explanation of the cause he assigns for the rolling of ships where it occurs in a comparatively smooth sea, and where no waves are perceptible—a case which constantly arises; and also how far the velocity of the translatory motion, whether that arises during the roll of a ship, or in such a case as the advancing surf in the drawing, how far the velocity of the translatory motion tends by the law of the composition of forces to make the pendulum assume a direction which it would not otherwise have taken. Also with regard to the cup full of water retaining a plane parallel to the wave slope, how far that would be true of a vessel of water if set on the deck of a ship—what would be the action of water inside a vessel set on the deck of a ship as compared with that which he attributes to the cup swinging in the hand which he has shown us?

Mr. FROUDE: With reference to the translatory motion of a wave, I think if you

were to place an upright post in moderately deep water traversed by a series of moderate waves, and to place a piece of cork on the water close to it, you would see actually that cork—at least I have never found any difficulty in seeing it—the cork move forward hollow at the crest and backward in the wave. I cannot say you ever see waves regular enough to show the absolutely circular motion, but you do simply see that the motion is of that character. You must recollect the translation of the profile of a wave itself is vastly greater than the translation of the particles of which the profile at the moment consists. Take the condition of an Atlantic wave, 500 feet in length, the transit of which, from crest to crest, will take ten seconds, making 50 feet per second as the speed of the translation of the profile. Now suppose the wave to be 20 feet high, so that the cork float at the surface is describing a circular orbit 20 feet in diameter, of which the circumference is, therefore, in round numbers, 60 feet, or a speed relatively so insignificant that an observer would certainly be unable to appreciate it correctly in the open sea when masked by the eightfold greater speed of the wave-profile; yet if, when the wave was passing him, he had a fixed object by which to observe its motion, he would be satisfied that the motion is at least 3 or 4 knots, as it really is, and that the top of the wave is moving forward, and the bottom of the wave is moving backward with about that speed, I won't say he could exactly count the speed by a watch, but he would be satisfied as to the character of the movement. With regard to the action of waves moving near a vertical quay wall, when the motion is *along* the wall, you do see the very thing happen. The case when the wave is approaching the wall no doubt may at first sight seem perplexing, but the fact is, that the existence of the wall converts the translatory motion of the contiguous particles, wholly, and of those nearly contiguous, partially, into vertical motion, and the increased rapidity of the up and down motion serves to disguise to a great extent the lateral translation which remains; but that it exists is quite unquestionable. If they are calculated, you will find that in all cases the actual translations are such as to correspond with the deflection of the pendulum, in virtue of the composition of forces, no less in the very flat waves which Captain Selwyn referred to, than in those of larger elevation. The composition of forces governs the result wholly. The forces to be compounded are gravity, which, strictly speaking, must include the vertical translatory forces due to such up and down motion as there may be, and the horizontal translatory forces due to such lateral motion as there may be. If you place a bucket of water on the top of a piston rod, and make the piston ascend and descend, then while the bucket is being accelerated upwards, there is an intensification of gravity in the water; when the bucket is being accelerated downwards, there is a diminution of gravity in the water, and you might make the acceleration so great that the water would be left behind altogether, and in that condition when gravity is neutralised by the downward acceleration, the water particles are in a perfectly neutral condition so far as mutual pressure is concerned. The water rising and falling up and down the face of a quay wall is very nearly in that position. It is thrown up, it is losing upward velocity and gaining downward velocity as fast as gravity can urge it, and therefore a very small lateral translation satisfies the condition that the surface of the water shall be at right angles to the compound of gravity and translatory force, even when the surface appears almost perpendicular. I do not know whether this explanation seems sufficient, but if you watch the phenomena by light of the explanation, I think they may be more correctly apprehended, and, as I have said, if you plant a small post in the water for the waves to wash past, you will see the very thing happening.

I think there is a little misconception in supposing that the mechanically rigid surface of that wheel can be taken to represent the living curvature of the hollow of a wave. Even were the wave-profile circular, that circle would not be the orbit of the particles. Even if the wheel were rotating, the pendulum would not hang normal to its circumference, nor if you were to put a drop of water on the circumference, would the water stay there. The pendulum might become horizontal in some part of the rotation, were the velocity sufficient, and the same circumstances would keep the water-surface in an upright condition, which would keep the pendulum in the horizontal condition. The length of the pendulum is important only because a very short pendulum is capable of at once assuming that position which is for the moment its position of equilibrium; a long pendulum, if not in that position, would be so long

assuming it that it would set up an independent oscillation. The short pendulum so instantly gravitates in the direction which is its momentary position of rest, that no time is lost. If you put a spirit level on a raft, if you put a marble in a floating saucer, and put them on regular shaped waves, the marble should not roll about; the bubble of the spirit level should remain at rest; the fluid in the spirit level is but as the fluid which surrounds the spirit level. Imagine a raft consisting of bamboo canes on a wave slope, you would be surprised to see the water running down through the canes; in fact, if a tube floats like a spar, pointing up a wave slope, the water should surely remain in it as inert as it appears to be in the rest of the wave-surface; yet the water is not really inert in the wave slope or in the tube, for the steady slope bears witness to the forces by which it is being urged.

The CHAIRMAN: I am sure you will wish me to thank Mr. Froude in your name most cordially for having so clearly explained a very difficult subject, for every Naval Architect and every seaman must feel it is one of the most important subjects that can be investigated. It is only during a very few years that the question of the theory of wave-oscillation has been scientifically and experimentally entertained at all. I suppose we could count on our fingers the men in Europe engaged in this investigation, and of these Mr. Froude stands almost foremost. We know the great difficulty there is in obtaining accurate records of a ship rolling. It is a matter of the greatest practical and scientific importance to the Naval Architect and the seaman in determining the disposition of the weights in a ship. We all know that it is practically a very great difficulty to ensure that the oscillations of a ship in a sea-way are truly recorded, and if this instrument assists us in accomplishing that object, and I fully believe it will do so, we cannot overrate its value, for it will enable our Naval Architects to deduce laws from the facts thus recorded, that will be of the greatest value to them. As regards the determination of the wave-slopes, I share with Captain Colomb the feeling that I am only learning this evening, and I cannot say I thoroughly have understood all we have heard, although Mr. Froude has made it so clear, but it appears to me one of the great values of ascertaining the wave-slope in connection with the angle of heel, is that you make your curve of stability of great importance in enabling you to ascertain the righting force acting on a ship when rolling, which the curve of stability in ordinary cases enables them to do when inclined in still water; but without knowing the angle of the wave-surface, the righting force cannot be ascertained. I have shared the difficulty that I heard expressed by Dr. Hirst as to the question of the inclined position of the pendulum, but I am ready to put faith in Mr. Froude, and only hope that he will be enabled by taking his instrument to sea to carry out his experiments further, and to prove to our satisfaction that what he says on that point, really exists. I may make one remark on it which perhaps may show how little I do understand the question. I cannot recognise that the pendulum can remain in the position of a normal to the wave-slope, except with some definite velocity of translation of the ship and a definite length of the pendulum. Experiment may satisfactorily prove that I am mistaken; but I should imagine the velocity of the translation of the point of suspension, and the length of the pendulum, were elements that must be taken into consideration.

Mr. FROUDE: It is because the ship is being translated by the wave at a certain rate, or rather because its translation is being altered at a certain rate, that the pendulum is deflected. The proposition is that there is inherent identity between the causes which govern the slope of the water-surface and those which govern the direction of the pendulum.

The CHAIRMAN: There is another point that I have no doubt experiment will prove. It is this: that that representation of the float partakes entirely of the motion of the surface, whereas a ship drawing 4 or 5 feet of water cannot entirely partake of the motion of the surface.

Mr. FROUDE: The diminution of the motion in the underlying water no doubt somewhat lessens the effective wave slope, which is thus different from the surface wave slope; the action is a compound action. I speak of the surface generally, merely by way of expressing the general laws which are in action without going into the complexity of the internal mechanism of the wave; this alters slightly the measure of the results, but does not alter their character.

The CHAIRMAN: I beg to offer Mr. Froude the most cordial thanks of the Council and audience for his most interesting paper.

Evening Meeting.

Wednesday, April 9th, 1873.

REAR-ADMIRAL SIR ASTLEY COOPER KEY, C.B., F.R.S., President of the Royal Naval College, Greenwich, in the Chair.

ON THE ACCURATE FIRING OF NAVAL ORDNANCE BY MEANS OF THE VESSEL'S MOTION.

By H. BESSEMER, Esq.

BEFORE commencing to read my paper, with your permission I will make one or two remarks on the models which I brought here on Monday evening last, as they serve further to illustrate the very admirable paper read to us by Mr. Froude. He, as you know, read a most elaborate and able paper on "wave-motion," and a mode of recording it. The instrument which I have constructed, and to which I refer, had not that object, but was simply intended to record the motion of the deck of a ship, that is to say, the amount of roll, and the amount of pitch of the vessel. In my own particular case, the invention had reference to the "still-cabin," which, as you well know, I am proposing to make for ocean travelling. For that purpose, I did not require that the instrument should be able to indicate through so great an angle as is necessary with the instrument produced by Mr. Froude, and some differences in our apparatus necessarily resulted, in consequence of the different objects we had in view. The first instrument which I proposed for this purpose was simply a curved spirit level. Here the tube, which is usually straight, is curved to an arc of 28 inches and $\frac{3}{8}$ths in diameter, giving quarter-inch divisions for each degree of the circle. The smallest roll of the vessel allows the air-bubble to play along this curved tube, and to present itself opposite each of these divisions, whether it be in one direction or the other, and a person observing it, is able to read off there and then, the angle through which the vessel is rolling. I wished to be able to indicate what was the actual difference between the rolling of the saloon as

constructed by myself, and the rolling of any other part of the vessel at the same moment; therefore an instrument in each place would have indicated accurately those differences. However, I found that a small amount of time is occupied in the traverse of the bubble, even for the short distance of $\frac{3}{4}$ of an inch, because it does not move until a change of level has taken place; hence I was very desirous of making an instrument that would indicate instantaneously the slightest alteration of the level of the saloon, and for that purpose I constructed the one we have here, and which owes its power of registration not at all to the same principle as the spirit level, but simply to the *vis inertiæ* of a large mass of metal.* I was very much struck and surprised to find on my entrance here on Monday evening, that Mr. Froude had adopted precisely the same means, and had carried out those means in the most perfect manner imaginable. The fly-wheel that he employed, had an axis of an inch in diameter, and rested on large segmental quadrants, which gave to it an exceedingly small amount of friction. In my case, as I only required to register one degree of motion—for I hoped to confine the cabin to an extreme range of only one degree horizontally—I have a means of indicating one degree, by a traverse of 3 inches, and the indicator will show the smallest amount of that motion; so that the instant the smallest deviation from the true horizontal line is given, the man controlling the apparatus has notice of it, and would be able to check it momentarily. I may say that this in reality is a pendulous body, although I speak of it as a large mass having only the *vis inertiæ* of its bulk to keep it from motion. By turning this screw a little, a cylindrical mass is projected from its under surface. While it remains in coincidence with the surface, the mass is in perfect balance, and is a portion of a perfect sphere; but the moment I begin to operate upon it, I project a pendulum. I have now projected it about $\frac{1}{8}$th of an inch; this is now a pendulous mass, but surrounded by so large an inert body of matter at its centre, that the portion projected does not tend to put it in a state of vibration. This instrument can be now swung backward and forward without the small protruding portion of metal having sufficient power to carry the mass with it. At the same time the tendency for the mass to hang vertically below the centre, is just sufficient to prevent any accidental imperfection of the axis from gradually getting it round to one side or the other, so that in reality this line of the screw which passes through the pendulum, is always kept vertical, however much the base may roll. This is precisely the principle involved in Mr. Froude's beautiful machine. The only difference is that he placed his fly-wheel eccentrically, some $\frac{6}{1000}$th part of an inch, which gave it a slightly pendulous action, while I, by protruding a pendulous mass can restore it to an absolute balance, or project it to any minute increment beyond that distance, that may be found desirable.

There was one other point in resemblance, which is a curious coincidence, because the machine of Mr. Froude's was one thoroughly elaborated, and one certainly of very great mechanical merit, though I was

* Diagrams, and an explanation of this pendulum will be found at page 899.

somewhat disappointed to find that he did not dwell upon that point. Indeed the first part of his paper was so interesting that he could hardly come to the details before he found the time was sliding away from him, and he omitted the latter part, which I presume dwelt more upon the details. You will remember he exhibited on one side of the machine a tracer with a very long horizontal pendulum, a thing, I believe, absolutely new. But it is curious that in the course of the investigations which I have now going on, I have employed two pendulums (made a year and a half ago), for the purpose of that very experiment. Here we have these two little pendulous bodies which never know when to cease vibrating, from the shortness of their axes. It was a matter of considerable surprise to me to find that this should have been so cleverly and so usefully introduced into the beautiful machine of Mr. Froude's. Having explained these models, I will now read my paper.

The British Navy has achieved so enviable a position before the world as to have attracted to itself and absorbed among its own members many of the most able and scientific men of the day, who, by their combined talents, have well sustained its high position; but while doing so, they have created so deep an interest among those who have not the honour of being connected with the profession, that numbers of persons wholly outside the sphere of its immediate attraction, have nevertheless been irresistbly drawn into the great vortex which requires and absorbs so much of the latent talent of scientific men.

Thus it is that I find myself as a mere outsider, taking so deep an interest in the science of naval gunnery, notwithstanding that my entire want of professional knowledge should have warned me that I was treading on dangerous ground, and at every turn liable to fall into grave mistakes; hence I must throw myself on your indulgence in venturing to bring before so many able naval men a proposal to improve upon a science, so many of the details of which I am totally without a knowledge of.

No one, however far removed from the profession, can have failed to note the great change which has come over the art of naval warfare within a very recent period. The employment of steam power in lieu of sails, the iron armour-plated ship, which now takes the place of our wooden walls, and the employment of heavy rifled ordnance in lieu of our old eighty-fours, have so revolutionised the naval profession as to have left but few of the old landmarks visible; indeed, it would seem that the whole profession has had to be relearned, and thus, with its ever-increasing changes, it now affords an opportunity, even for outsiders, to offer an occasional suggestion for its improvement.

The employment of war vessels of the new type, carrying very few guns of large calibre, instead of a large number of small ones, renders it very desirable that those which are employed should be handled with the greatest facility, and that every shot fired from them, as far as practicable, should be made to tell; at least this is the view which I, as a non-professional man, have taken to be one of paramount importance.

Among the most remarkable effects of our modern rifled artillery is the extreme accuracy obtained when firing from a steady platform on shore; the results thus attained have served most forcibly to illustrate the extreme *inaccuracy* of firing with the same class of gun from an unsteady platform at sea, where the advantages of the high perfection and precision of modern rifled artillery seems almost wholly lost.

It is now more than three years since the disadvantages of an unsteady platform in passenger vessels was forced on my attention by a severe illness produced by crossing the Channel in rough weather, and almost simultaneously with my earliest attempts to lessen the causes of sea-sickness, the idea of a steady platform for guns forced itself on my attention, but without however inducing me to pursue a branch of the subject with which I had no immediate connection, I nevertheless described in my Patent of June, 1870, a mode of supporting guns on a movable platform, capable of being controlled and retained in a horizontal position by hydraulic machinery, similar to that by which I propose to govern the suspended passenger saloon; but on a more mature consideration of the question, I perceived that there would be considerable difficulty, if even it were possible to obtain a platform so uniformly horizontal and steady as to really represent a platform on shore. With this want of confidence, the matter was left until very recently, when the public discussion of my steady saloon for passenger steam-vessels attracted the attention of Colonel A. Strange, who, wholly unaware of what I had proposed in reference to gunnery, re-invented the steady platform for guns, governed by my hydraulic apparatus; and on which subject you will remember that Colonel Strange read before this Institution a most interesting and able paper a few months ago.

The importance of a steady platform for guns at sea had sufficiently forced itself on my attention, in 1870, to prevent it from being entirely forgotten; hence the subject, from time to time, continued to occupy me until January, 1871, when I first conceived the idea of utilizing the motion of the vessel, and making it the unconscious agent by which a gun may be fired at any desired angle of elevation, and thus, in lieu of struggling to obtain a quiet platform, I sought to bring the restless enemy, not only under subjection, but to make it an unwilling instrument in bringing about that amount of accuracy of fire which, from the earliest days of marine artillery, it had so persistently counteracted.

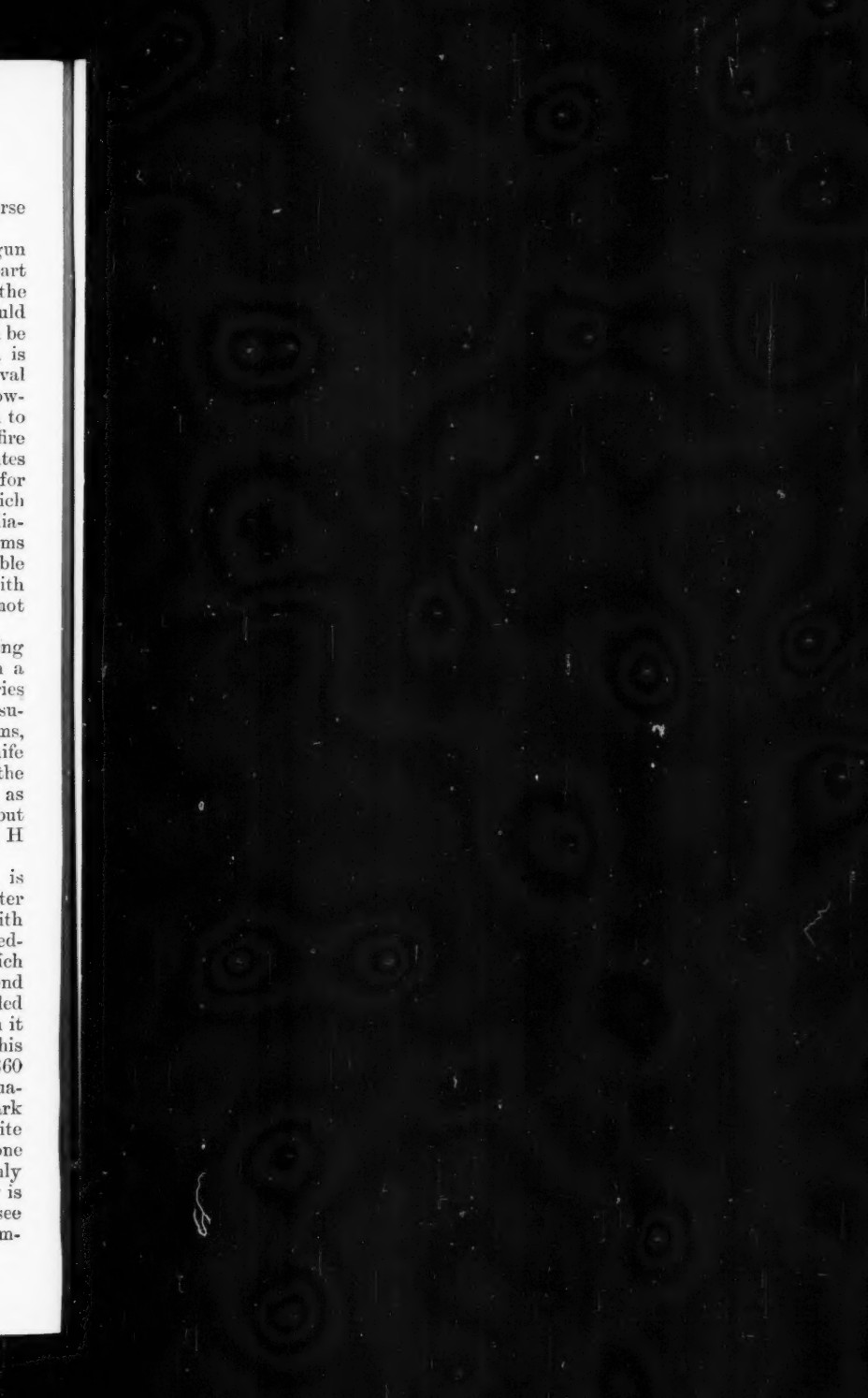
Let us now suppose a broadside gun about to fire at a vessel a quarter of a mile or 440 yards distant from it, and that the vessel on which the gun is placed rolls to an angle of six degrees, and that she makes eight of these rolls per minute, it follows that at every such roll the gun will be directed to a point 69 feet above and 69 feet below the centre of an arc of 138 feet, described at a distance of 440 yards from the muzzle of the gun. This gives a mean speed of 36·8 feet per second, at which the imaginary arc is described; so that for one-third of a second of time only, does the gun cover the 12 feet in height of the side of the enemy's vessel, even when it is within a distance of only 440 yards. Need it then be a matter of surprise that our most expert gunners under such circumstances make what would be very bad practice on shore,

but which is nevertheless a perfect marvel of skill under these adverse circumstances.

Now it occurred to me as a necessary consequence that as the gun at every roll of the ship points so many feet above and below the part which we desire to strike, that at every such movement of the vessel the gun must necessarily point precisely at the desired spot, and if we could only ascertain the right moment to fire, that our practice at sea would be as certain and effective as it is on land; and further, that all which is necessary to accomplish this object, is to confine the skill of the naval gunner to the training of his gun, and to the employment of his knowledge as an artillerist, in determining the proper angle of elevation to fire at, and to furnish him with an instrument which would itself fire the gun with unerring certainty at any number of degrees and minutes of elevation at which it may be set, leaving him to choose the time for putting the apparatus in operation. This, then, is the instrument which I propose to employ, and which is shown in front elevation on the diagram, Fig. 1, and in side elevation of Fig. 2, a portion of both diagrams being in section. I have also an instrument so constructed on the table before us. The instrument may be placed upon or near the gun, with its base-plate in the same plane as the chase of the gun (which will not require to be altered).

On the base-plate, A, the table, B, is supported on an axis, C, resting on Plummer blocks, D. The central part of the table is filled with a block of vulcanite or other non-conductor of electricity, E, and carries in its central part, a grooved strip of brass, G, which is, therefore, insulated. The block of vulcanite also serves to support two brass arms, H and I, between which is an inverted pendulum, J, resting on knife edges at its lower end, which are inserted in the groove formed in the piece of brass, G. The pendulum, J, is much widened at the foot, as shown at J*, Fig. 2, and is thus prevented from falling out of place, but it is nevertheless free to move to or from the supports or arms, H and I.

On the same axis as the table, E, a graduated quadrant, K, is mounted, the curved edge of which is in gear with the micrometer screw, L, by means of which it is made to carry the table, B, over with it to any desired angle of inclination. It will be observed that the bed-plate, A, also serves to support a frame, M, in the upper part of which the axis of the micrometer screw works. This axis carries on one end a milled thumb-screw, N, and at its opposite end a small disc, P, divided into sixty equal parts or minutes. The quadrant has engraved upon it a central zero, and twenty graduations in each direction from this central point. These are simply degrees of a circle divided into 360 parts; thus, one revolution of the micrometer screw moves the quadrant exactly one degree, while the divisions on the disc, P, each mark one-sixtieth, or one minute of a degree. It has been thought quite unnecessary to make any further division of the arc into seconds, as one minute of a degree alters the point where a shot should strike only $4\frac{1}{2}$ inches at a quarter of a mile distant. A small galvanic battery is employed, and one of its conducting wires is inserted in a stud (see Fig. 2, which forms part of the grooved piece of brass, G), and thus, com-



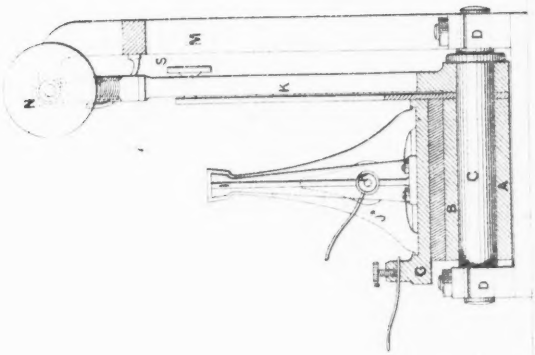


Fig 2

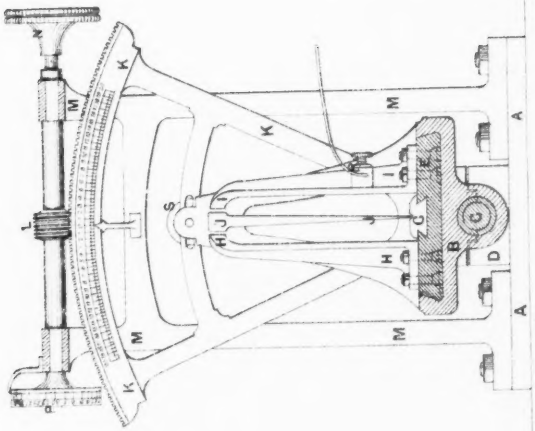


Fig 1

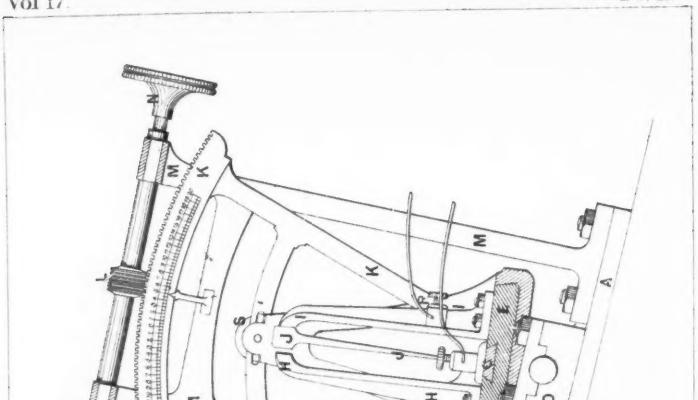


Fig. 4

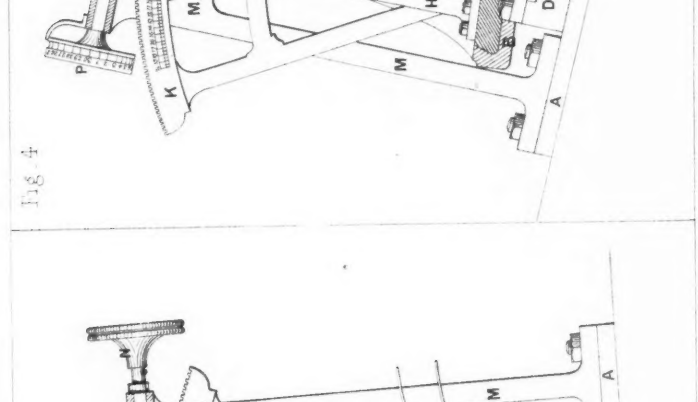


Fig. 5

J. Jobbins

municating with the pendulum, a similar wire attached to the stud, R, on the arm, I, communicates with an "Abel's Fuze" in the gun, and from thence again to the battery.

A small movable spring knob is placed in convenient proximity to the gunner, and will, on being pressed upon, make good the connection with the wire leading from the battery to the pendulum, but this spring knob will always leave that connection broken except when it is pressed upon.

Such being the arrangement, it will be understood that with every roll of the ship the pendulum resting against the arm, H, will be brought up to a vertical position, and will then immediately fall over against the opposite support, I, and in doing so will at the moment of contact, establish a direct metallic communication between the battery and the fuze, provided the spring firing-knob is being pressed upon, and not otherwise. But whenever the instrument is in the position shewn in Fig. 3, the pendulum, J, resting against the arm, H, cannot communicate with the fuze, because this arm rests on the vulcanite, and is insulated, but whenever the pendulum passes the vertical line as shewn in Fig. 4, it falls over and rests against the arm, I, and instantly fires the gun. It will be observed that the instrument shewn in Fig. 4, has its quadrant turned to an angle of 5 degrees, and it is not until the base of the instrument rises to this angle that the pendulum can fall over; and as the base of the instrument is coincident with the plane of the chase of the gun, the discharge will take place at that angle of elevation, and at no other: thus as soon as the gunner has determined at what angle he desires to fire, and has moved round the micrometer screw, until that angle is indicated on the instrument, he may discharge the gun, or he may continue inactive as long as he pleases, meanwhile every roll of the ship will cause the pendulum to make and break contact, but all to no effect until he presses the firing knob, and thus joins up the remaining link in the connection between the battery and the pendulum. Here it must be specially observed, that the act of pressing down the firing knob does not discharge the gun there and then, but paves the way for its discharge by the falling pendulum, which only obeys this summons when the chase of the gun has arrived at the precise angle indicated by the instrument.

Now the instrument, so far as I have hitherto described it, is subject to two sources of error, which are provided for in the following manner:—

Firstly. It may be observed that a pendulum falling freely through the space of $\frac{1}{4}$ of an inch, occupies a small space of time in so doing, during which the roll of the vessel continues to alter the angle of the gun's elevation; and secondly, there is also a small period of time during which the shot is traversing the chase of the gun after the powder is ignited, and during this period also, the roll of the ship continues to alter the elevation of the gun. A second movement on the instrument is provided therefore for the correction of these two sources of error, and is effected by means of a thumb screw, as shewn at S.

From actual experiment with the gun, this loss of time can be correctly ascertained, and a correction must be permanently made on

the instrument whereby the zero or horizontal point is no longer an absolute zero, but a working zero; the instrument will then indicate, not the angle at which the pendulum will commence to fall over, but the actual number of degrees and minute of elevation of the chase of the gun, at the precise moment that the projectile is leaving it, and thus afford the gunner at sea the same opportunity of hitting the object aimed at, as he would have after taking a most deliberate aim with a gun mounted on a fortification, and carefully directed on a like floating object.

I desire further to observe that the instrument I have placed before you although sufficient in size to fire the largest artillery, may perhaps be preferably made much larger and coarser than this one, an instrument in fact consisting of a strong cast iron frame bolted down to the floor alongside the gun, and capable of sustaining rough usage without injuiry.

Further, I would observe that an instrument which I call a "motionless pendulum," devised for the purpose of governing the ship's saloon, may also be made use of in lieu of the inverted falling pendulum, because its indications and action upon objects in motion, are more rapid than the instrument I have just described; indeed it will be obvious that many modifications may be made of this instrument depending on the broad principle of my invention, viz., the firing of ordnance at sea, at any precise and pre-determined angle of elevation, by means of the rolling, or pitching motion of the ship, totally irrespective of the extent of such movement.

There are two other points which I conceive to be necessary in order to complete the proposed system of accurate firing at sea.

Firstly. I propose to use an hydraulic apparatus capable of most easy control by a sort of steering-handle similar to that which I employ for the control of ships' saloons, and by means of which the gun may be so trained, that the line of fire shall at all times pass to and from a point vertically above or below that part of the vessel which the gunner desires to strike, irrespective of the varied motions of the ship on which the gun is carried. The instrument employed for firing, may be placed alongside the gun, and have its base-plate pivoted so as to form a sort of turntable, having a rod to connect it with the traversing carriage of the gun, so as to retain the relative positions of the pendulum and gun always the same, and thus insure its perfect action.

Secondly, I consider it necessary that the gunner should be provided with an instrument capable of measuring rapidly the exact distance of objects at sea. I had devised a very simple instrument for this purpose, and it was included with two others in my application for a patent for the instrument now before you.

But these instruments were considered by the Solicitor-General to be separate inventions, and he required that I should take out separate patents for them, although they each formed part of a system of accurate firing at sea. The result was that I only took out a patent for the one instrument now before us, and the others have in consequence only been partially developed. The instrument for measuring distance, consists of a trigonometrical arrangement combined with a powerful field-glass

on which a micrometer screw and index show in plain figures, and without any calculations, the number of yards distant of a ship, by simply turning a thumb-screw while observing the distant object. The time required to make an observation would be about thirty seconds, and this might be called out to the gunner continually as the vessel advances or recedes. From a rough trial I should say that it would indicate objects at half a mile distant with an error not exceeding three yards.

I am thus led to believe that, with the self-acting apparatus to discharge the gun at a determined angle, guided by an efficient instrument for indicating the distance of the object fired at, and with the hydraulic apparatus for continuously training the gun, a degree of accuracy in firing at sea would be achieved, that the utmost skill of our best naval gunners must for ever fail to reach under existing conditions. Now also that our guns are reduced to so small a number in every ship, it appears to me of the highest importance to the service, that every available means should be employed that can assist the gunner in rapidly manœuvring the gun by the application of power, so as to save labour, to reduce the number of valuable lives exposed, and to neutralize, as far as practicable, the sources of error in training caused by the motion of the vessel, and in determining the exact instant for firing by a properly constructed instrument; for it must be of immense advantage to deliver the first blow, and to follow it rapidly up by others. Indeed if we could succeed in doubling or trebling the number of effective shots, it would be equivalent to an equal increase of the number of guns and the actual force of our Navy, the importance of which question no persons are so well qualified to judge of, as the gentlemen whom I have had the honour of addressing.

Vice-Admiral Sir SPENCER ROBINSON, K.C.B.: Of course the gun in this case is to be laid horizontally? The motion of the ship is to give the elevation, to be determined by that screw (*pointing to it*), and whenever the motion of the ship gives the elevation necessary, the gun is then fired automatically?

Mr. BESSEMER: That is the arrangement precisely as it stands, but it does not necessarily follow that rule, inasmuch as if it were necessary to fire when a ship was rolling only one or two degrees, and you wanted a third degree of motion upon it, you would place the angle of your gun so that the two degrees of motion would include within it the degree at which you must fire.

Sir SPENCER ROBINSON: I should like to address a few remarks to the meeting upon this most interesting subject. I say it is a most interesting subject, because I am sure all of us must feel that the invention of an instrument of this kind to do away in some measure with the uncertainties of naval ordnance discharged under motion at sea, is an enormous gain to the naval service, and at any rate, whether a gain or a loss to us nationally, will have upon naval tactics, upon the results and conditions of naval warfare, a most extraordinary effect. There are none of us who I think of late years have considered the subject, but have been overwhelmed almost, by the immensity of chances against the terrible projectiles which we are prepared to discharge, hitting the object at which they are aimed. It has seemed to me, on reflecting on these subjects through a considerable period of years, that we have incurred a very great and incommensurable amount of uncertainty as to the effects of naval ordnance at sea. We have reduced the numbers of the smaller ordnance which were formerly carried, 32- and 68-pounders, and have culminated now in that 35-ton rifled gun, shortly to be superseded by a 50-ton gun. (If the artillerists can succeed in building such a gun to their satisfaction, there is no doubt we shall

shortly see it.) The effect of diminishing the number of guns, is that it is obvious in a naval action the chances of our projectiles hitting are diminished in inverse ratio of the power of the projectile when it does hit. We shall deliver the most frightful blow from the 35-ton gun; we shall deliver a blow that hardly any structure can resist; but we shall deliver that blow slowly, and we have not made as much progress in certainty of hitting with that tremendous projectile as we had formerly by a discharge of from ten to twelve 68-pounders. If our shot is not thrown away, the effects will be destructive and final; if our shot is thrown away, a long time will elapse before we shall be ready with another, which also may fail. To my mind, the influence of this hazard of not hitting, on naval tactics and constructions, is very great. Naval battles will be fought, as I conceive, at sea, under conditions of rapid motion through and rapid motions upon the water, and therefore under circumstances in which artillery must be admitted to be uncertain, and it is probable that the most efficacious mode of destroying an enemy will be, by the fearful impact of one of these vessels against another. However, I was very much struck by the wonderful adaptation of mechanical thought that Mr. Bessemer has displayed in the admirable machine that he has put before us. He has, if I may so say, eliminated one of the great difficulties of this subject, one of the great causes why the effect of naval artillery is likely to be considered very uncertain—he has eliminated one of those great causes by inventing a machine which will evidently discharge a gun at the exact moment that we have got the elevation that is required for propelling the projectile through the space it has got to travel, and causing it to alight on the object it is aimed at. That we know was by no means an easy matter in former times, and upon that, upon the right elevation of the gun and upon its being discharged at the right angle of elevation, a very large and important part of the chances of hitting the object, as we all know, depends. The procuring a right direction of fire is not so difficult. Discharging the gun at the due elevation, when elevation is required for a projectile to go to its mark, is no doubt a considerable difficulty under motion. It appears to me that the whole subject is so perfectly thought out, that no merely mechanical difficulties will prevent the success of this machine, and that the plan Mr. Bessemer has brought before the meeting to-night, will no doubt be perfectly effective in discharging the gun with the elevation it ought to have. If that be combined with the exact knowledge of the distance, so that the elevation is really what it ought to be, we have eliminated a very large source of error from the discharges of naval ordnance, and naval ordnance of large calibre may be looked at with more satisfaction than we can look upon it under the present knowledge of the uncertainty of its results at sea, because the loss of time in loading these large 35-ton guns or, supposing we get it, in loading a 50-ton gun, and discharging it, would be very considerable. The rate at which ships approach each other has now become something enormous. We know that we possess ships capable of going within a very few decimals of 15 knots an hour. Our neighbours possess ships capable of travelling at very much the same speed, and ships approaching each other at 30 miles an hour leave us but small time for more than one discharge, and if that discharge fails, the combat resolves itself almost entirely into impact. Like the knights of old, we shall probably retire and charge again. If, as I say, we get over the uncertainty under which we now labour of discharging the gun at the exact moment it has the proper elevation, we have eliminated one very great source of uncertainty from the action of naval ordnance at sea: we shall feel greater satisfaction at having thrown away numerous pieces of small artillery and adopted pieces of enormous dimensions, slow in their fire, but most formidable and most deadly in their effect. I think the subject is well worthy of the attentive consideration of this Institution, and it occurs to me that Mr. Bessemer has brought before us something which will be of very great value in deciding, not only on the forms of our ships which, after all are nothing but floating gun carriages, but upon the nature of the gun itself, and in bringing out a fact that will give us an assurance that we are not altogether wrong in constructing those huge pieces of ordnance, whose effect will so greatly depend on the success of these inventions that he has brought before us. I attach very great importance to the small machine he described for letting us know the exact distance we are from our opponent. I think we shall derive the greater benefits from the perfection of such instruments as these, the larger the ordnance we

employ. They will enable our artillery to be directed with more confidence of hitting the object under the rapid motion of the ship and at the extraordinary angles at which the projectile must at times leave the gun than we can possibly have at present, even when we are in the hands of the very best and most skilful artillerists. I go further also in this view. It seems to me the more we follow out progressive science, the more we investigate the causes of all that passes under our observation, the more we come to this conclusion—that when we can bring well-conceived machinery automatically to do the duty that we wish to put upon the nerve, upon the skill, upon the brain, and upon the teaching that any man has received, the more we eliminate error, and the more nearly, we approach perfection. I have seen within the last few weeks some very remarkable proofs of how matter taught by mind can do things which mind alone cannot do. I listened with the greatest interest the other day at the Institution of Naval Architects to the description of that model for ascertaining the rolling of ships, given by Mr. Froude. I see in the instrument that Mr. Froude has invented and in the one that Mr. Bessemer has put before us, proofs of the enormous power of direction, that a mechanical mind has over matter, and of controlling that matter by mathematical reasoning. We remember the wonderful way in which the late Mr. Babbage used mechanical means to solve some of the most abstruse problems in the philosophy of arithmetic by a calculating machine. When we see these automatic machines, by which a gun can be discharged with scarcely calling for the operation of a man's mind—that the gun itself when put into position by the ship's motion will be discharged at a given object at precisely the elevation at which that object can be hit—when we see that mechanism can be applied to calculation, that mechanism can be applied to register with the greatest accuracy, not only the rolling of the ship, but to describe actually the path of the wave and the influence of that wave over the ship's motion, I think we must all feel the greatest possible desire not only to encourage, but to take part as far as we possibly can, in these applications of the reasoning powers of men to mechanical applications, remembering that it is thus that large and important addition to our powers of acting on the forces of nature will be given to us. Before I sit down I must say that amongst all the things that have given me pleasure, one that I have the greatest delight in recalling is the fact that a Naval College or University has been established, in which all such inventions will in the course of time be brought before the rising generation of naval Officers, and also that that University will be under the presidency of a naval Officer whose talents and abilities to fill the particular post, are well known to us. I am delighted to think that amongst the memorabilia of Mr. Goschen's administration—be they few or many—there is at all events this one, which will be appreciated by all who value knowledge, instruction, and the powerful influence they will exercise over the minds of youthful followers of the naval profession. Nothing that Mr. Goschen has done will redound more to his credit than the establishment of the Naval University and the appointment of the Officer to whom he has entrusted the Presidency of that University. I am sorry to have occupied your time so long, but having thought very much upon these subjects, and having myself felt the disadvantage of an imperfect naval education in these deeply interesting matters, I could not but congratulate you on the prospect there is before us of a better system of instruction being afforded to naval Officers. I must again express the value I attach to inventions such as Mr. Bessemer and Mr. Froude have brought before us, as showing the power of thought to overcome mechanical difficulties. I am delighted first of all that we have such an Institution as this one, and next that gentlemen like Mr. Bessemer and Mr. Froude will come and explain these things to us, and if I have taken up your time in talking about matters of such grave importance I must ask you to excuse me, for it is the fulness of the delight with which I have witnessed these things, that has compelled me to trespass so long on your attention.

Captain GODENOUGH, R.N.: It would be quite impossible for us to attempt to discuss the invention of Mr. Bessemer, any more than we could that of Mr. Froude, the two papers describing those inventions being the very last expression of science in the several directions in which they go. There is, however, one question that I should like to moot, in order to clear up a point on which Mr. Froude spoke to us the other day, because it seems to me that Mr. Froude and Mr. Bessemer are not perfectly at

one. We understood the other day from Mr. Froude, and I think we all accepted it on his authority, although we were hardly able to follow the whole of his very close and perfect argumentation, that the action of translation of a wave, of what he called the mean or virtual undulation of the wave, was such as to render anything in the nature of a pendulum, an inaccurate instrument: and, although in the instrument which Mr. Bessemer has applied for the laying of the floor of his cabin, that is (to speak in general terms) to a great extent counteracted by the great mass of the weight of the pendulum which he uses; still in this small instrument used for the firing of a gun, there is undoubtedly a pendulum of certain length of radius and of no very great weight, which is to be acted upon by the forces of gravity and wave-motion, in order to fire the gun. It appears to me that the motion of that pendulum will not be strictly normal to the required angle, that it will not fall or move from one side to the other, when it is truly vertical to the surface of the earth, if Mr. Froude's theory is correct, as we assume it to be. I do not mean to say that this will seriously or in any very great degree interfere with the firing of our ordnance at sea, because, as a matter of fact, we do not expect ever to fight an action requiring very accurate firing in such a sea as would give the ships any considerable motion of translation. Still, theoretically, it would appear that there is a divergence between Mr. Froude and Mr. Bessemer, and I dare say Mr. Bessemer will kindly explain it.

We should be very much obliged to him also if he would kindly allow a section of that globe to appear with the printed report of the lecture.

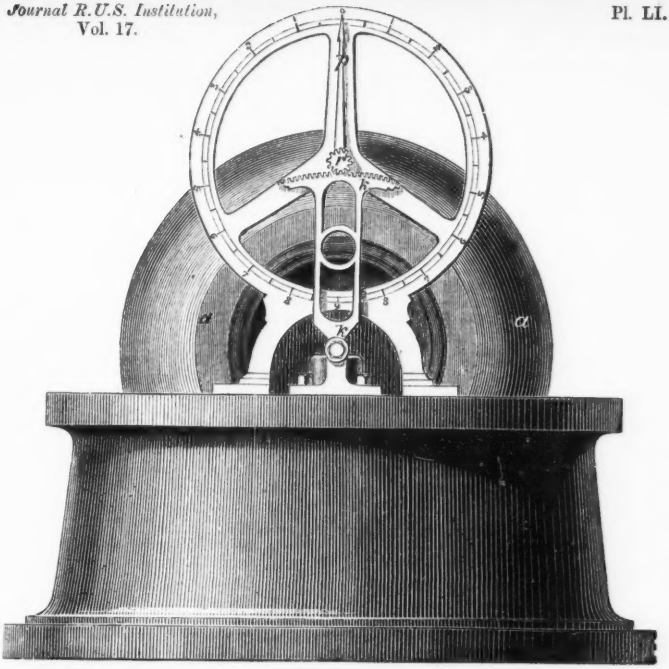
Mr. BESSEMER: If you will allow me, I will sketch a section of the apparatus on the board for you, and give an explanation of the point raised.

A cylindrical mass of metal, *a* (Plate LI), is mounted on an extremely small axis, *b*, composed of a polished steel wire, secured at both ends in the main axis of the mass, *a*. On the lower side of the mass of metal so suspended, is fitted a sliding weight, *c*, capable of being drawn up into the mass, and, when there, entirely filling the cavity, *d*, so that the mass of metal then becomes as completely balanced as it would have been, had no such sliding weight been provided.

You will perceive that the screw, *n*, passes vertically upward through the axis of the mass, *a*, having a collar at *e*, and a square end, by means of which it may be turned round, while its lower end is screwed into the sliding weight, *c*.

Now, if we suppose the cylindrical mass, *a*, to be for the moment taken away, we should have the weight, *c*, remaining suspended at the lower end of the screw, *n*, and capable of oscillating on the axis, *b*, after the manner of an ordinary pendulum, in which state it would (if on land and undisturbed) simply gravitate, and come to a state of rest with the centre of gravity of the weight hanging vertically beneath a line drawn through the axis, *b*. But on board ship the axis of the pendulum, like all surrounding objects, is subject to a motion of translation, produced by the rolling of the ship. Thus the point from which the pendulum is suspended would be no longer retained vertically above the centre of gravity of the weight, which would, in consequence, move in a direction necessary to recover its wonted position beneath its points of support. In doing so, it would acquire an amount of momentum sufficient to carry it beyond the desired point, and thus set up a series of oscillations which would continue so long as the translatory motion of the vessel lasts (and which in fact are continuous): hence all attempts to make a simple pendulous body freely suspended on shipboard, an useful indicator of the plane of the horizon, is impossible.

In attempting to modify the construction of a pendulum to escape these difficulties, I have suspended the instrument in water, which had the effect of greatly reducing its violent erratic motions, but, nevertheless, the old fault remained, though in a minor degree. It then occurred to me that this too easy movement of the pendulum would be lessened if I surrounded the axis with a heavy mass of metal in a state of perfect equilibrium, the *vis inertiæ* of which would to some extent oppose the too free action of gravity on the pendulum. This idea carried to its fullest extent is exemplified in the instrument before us, where the weight, *a*, entirely surrounds and absorbs, as it were, the pendulous body, *c*, so that when the latter is drawn up entirely within the cavity, *d*, the apparatus ceases to have any of the properties of the pendulum, and is in fact simply an inert mass mounted on axes, and in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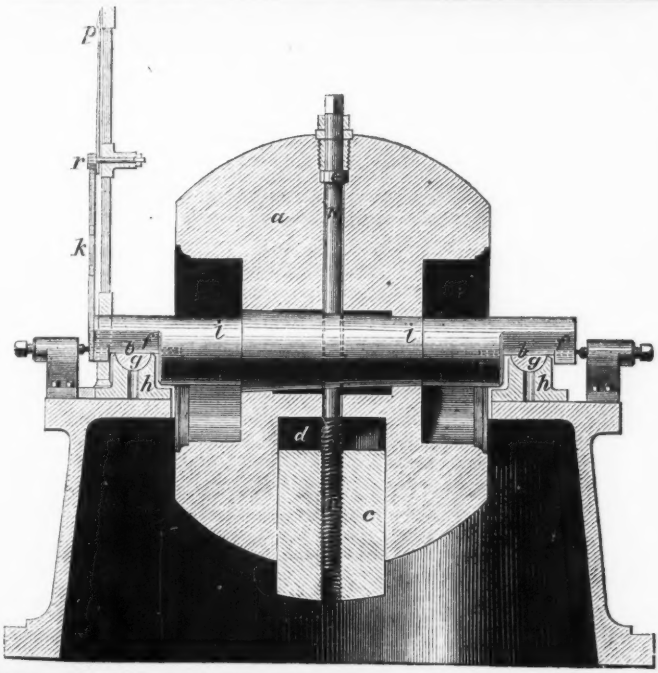
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a state of perfect equilibrium, and hence has no tendency whatever to acquire an oscillating motion by the mere translation of its axis, and will therefore under such motions of the vessel remain in a state of perfect rest as far as axial motion is concerned, provided that the friction of the axis is so small as to prevent the bearings, *g* (on which it rests), forcing it round with them. It was with a view to prevent all tendency of the mass, *a*, becoming gradually altered in position by this axial friction, that the weight, *c*, is employed, and which, by means of the screw, *u*, can be lowered to the exact distance required. That portion of the weight so lowered beneath the mass, will become so much pendulous matter, tending to keep the position of the mass with this pendulous matter vertically beneath it, while its action is nevertheless so small, that the translatory motion of the vessel cannot produce an oscillation of the inert mass, *a*, by reason of the small amount of pendulous matter forming part of it: hence we have an instrument capable of maintaining itself in a state free from any oscillation on its own axis, and capable of registering the motions of surrounding objects.

In order to allow of the movement of the supporting bearings, *g*, round about the axes, *b*, I have cut away three fourths of the main axis, *i*, leaving only a quadrant of the axis, as shown at *f*, and this remaining part serves to support the wire axis, *b*, which is only $\frac{1}{10}$th of an inch in diameter, and rests on the supports or bearings, *g*, the underside of which are fitted to hemispherical cups, *h*. Small grooves in the upper side of the bearings, *g*, retain the wire axes in place; the hemispherical form of the bearings allows them to adjust themselves to, and form an even support for the whole rubbing surface of the long slender wire axes, the rubbing surface of which traverses only over $\frac{1}{108}$th of an inch for each degree that the vessel rolls, and this distance on an axis so small as $\frac{1}{10}$th of an inch in diameter is incapable of transmitting motion to the mass, *a*, which weighs 300 lbs.

In order to register the number of degrees through which the ship rolls on a scale with coarse divisions easily read off, I fix to the main axle, *i*, of the apparatus, a toothed segment, *k*, in gear with a small pinion, *r*, the axis of which carries a pointer, *p*, so that a considerable arc is described by the pointer whenever the floor on which the apparatus stands is moved only slightly from the horizontal position.

With regard to the question of Captain Goodenough, in reference to the inverted pendulum employed in the apparatus for discharging guns at sea, I may observe that the term pendulum applied to such an instrument tends to convey a perfectly erroneous impression of its action, it is, in fact, not a pendulum, but simply what engineers call a "tumbling-bob," a mere weight supported on the top of a light bar, the lower end of which is brought to a sharp edge, which rests in a groove and is supported at its upper end between fixed brackets, against one of which it rests in an inclined position, until by the rolling of the vessel, it arrives at a point where the centre of gravity of the weight passes the vertical line, when it tumbles over against the opposite support, wholly free from those oscillations which accompany the swing of a pendulum, whenever its point of suspension is removed from a position vertically over the pendulous mass.

During the time occupied in the falling over of the weight, the ship's motion will continue to alter the elevation of the gun, and after the weight has fallen over and established an electric communication, there will still be an interval of time occupied by the traverse of the projectile along the chase of the gun, during which period the motion of the ship will continue to alter the elevation of the gun, and I compensate for both these sources of error by a special and permanent adjustment of the instrument, which may be most correctly effected by firing a shot through a screen placed a few yards from the gun, and so adjusting the quadrant of the instrument, that, when thus hitting a line marked on the screen in the same horizontal plane as the chase of the gun, the zero of the instrument is to be permanently altered, so that its zero point no longer indicates the period at which the weight becomes vertical and begins to fall over, but the instrument indicates the actual angle of elevation acquired by the chase of the gun at the moment the projectile escapes from its muzzle.

Captain Goodenough: Sir Spencer Robinson has said, in words much better chosen than I could possibly choose them, how much we are indebted to Mr. Bessemer

and to other men of science, who come forward like him to assist us in our endeavours, and I say further how gratifying a thing it is that in this country there is so much sympathy with nautical enterprize, and with the objects of the naval profession, that even people who suffer (as Mr. Bessemer does) on the sea, enter as warmly into these matters, as those whose profession it is to follow the sea. That is a subject of congratulation and pride to every Englishman. I may mention one thing in my own experience in confirmation of what Sir Spencer Robinson says about the superiority of mechanical means, even such as those we now possess on board ship, to that very imperfect instrument, a man's eye. We have recently fitted our ships with instruments by which we may fire the whole of our broadside by electricity. In the "Minotaur," with a broadside of 11 guns, we have frequently fired, first, broadsides by eye, and afterwards broadsides by electricity, with a mechanical arrangement. In the broadsides fired by eye, the captain of each gun stands at the end of his trigger-line; the guns are laid as near as they can be to the object, and the captains of the guns are directed to fire by a directing gun. The captain of this gun fires when the object is on with the point of his sight. With the other means—by electricity—the guns are all laid exactly by converging marks on the deck to the object, not by eye, but by mechanical means, to the same elevation, and they are then fired by communication from an observer at an instrument on the upper deck. We invariably found the broadsides fired by mechanical means were more accurate than those fired by the eye by the eleven men looking along the eleven sights of their guns.

Captain BURGESS: I should like to ask Mr. Bessemer to explain whether his instrument will answer with the pitching of a ship. That instrument is arranged for lateral rolling, but will it act also in the case of pitching?

Mr. BESSEMER: In fact it comes precisely to the same thing. If you were to place the instrument parallel with the line of the gun, whether the gun is projected from her bow, or the side, or any angle between those, which angles you get by training sometimes, it comes to precisely the same thing. When the chase of the gun assumes the position indicated on the instrument, at that time it is bound to fire, and at no other. It is quite irrespective of the direction or the position the gun occupies on board the vessel. Whenever the gun arrives at the determined angle of elevation, the firing will take place.

The CHAIRMAN: I shall premise the few remarks I shall make, by referring to a very important point to which Captain Goodenough has drawn attention; it is this. Mr. Froude explained to us on Monday evening very clearly his theory (which he illustrated by experiment) of the action of a pendulum when a vessel is rolling on the slope of a wave. He stated that instead of the pendulum hanging in a vertical position when at rest, it would take up a position normal to the wave slope. I had the advantage after the lecture on that evening, of hearing further explanation from Mr. Froude on that point. It is a question that would affect the subject now before us most seriously. If Mr. Bessemer's inverted pendulum were used, no difficulty would arise, but if a sphere or any other pendulum were necessary, Mr. Froude's theory would, if practically correct, introduce a new element to consider. Mr. Froude said, however, that the pendulum would take up the position he had pointed out only when it was infinitely short. This is most important, as no practical difficulty will arise when considering the best mode of adapting a pendulum to fire heavy guns at a given inclination to the horizon.

I most fully concur with the remarks that fell from Sir Spencer Robinson respecting the great importance of improving the accuracy of our fire at sea, when the guns are so reduced in number, and guns and projectiles are so increased in size. We must all feel that although our ships have also improved in offensive and defensive power, we have not advanced in any way in the accuracy of our fire. The guns, being rifled, are as accurate as we can wish them to be, far more accurate than anything we ordinarily require at sea, but we are still liable to the same sources of error as formerly, when we had 120 guns in a ship of the line instead of four. Any step taken to eliminate even one source of error, is a most important point gained. I consider that Mr. Bessemer has shown us the way to do that. He has taken a step in the right direction by showing us how to take advantage of mechanical means instead of trusting entirely to a man's eye and nerve. It seems to me, however, that the

inverted pendulum exhibited here this evening is not an instrument that could be practically relied on; the sudden motion of a ship, such as that caused by a ship being struck by a wave on the broadside, would very likely make a contact at the wrong time. But it is evident that the system of the sphere or some other description of pendulum might be introduced with the same object. I do not know whether Mr. Bessemer has contemplated that. (Mr. BESSEMER: I mentioned it in the paper.) That is so clear that I think it is scarcely worth referring to. I am sure this is a matter well worth putting to the test of experiment, and that all naval men will be most thankful to see such an experiment carried out. I consider it is opening the door to an improvement in the accuracy of our fire in a seaway.

It would be uncourteous in me, especially as I see several members of the Naval College at Greenwich here this evening, if I did not refer to the remarks made by Sir Spencer Robinson when expressing his opinion as to the advantages likely to accrue from the Naval College lately established at Greenwich over which I have the honour to preside. I trust that they will prove to be all that the well-wishers of our service desire that they should be, and I can confidently say that there is no one in the service whose good opinion we should value on that point so highly as that of Sir Spencer Robinson's. With your permission I beg to offer Mr. Bessemer our cordial thanks on the part of the naval service for the trouble he has taken in investigating this difficult question, and for introducing what I believe is a step towards the improvement of the accuracy of our fire at sea.

Mr. BESSEMER: I can but express myself exceedingly gratified at the very kind way in which the shortcomings of my paper have been kindly passed over by you, and the very complimentary way in which you have been pleased to speak of the system which I have endeavoured to illustrate this evening. I can only say in reference to it, that, if the Government would place at my disposal for the purpose, a gun and the use of a ship for a day or two, whenever it suits them best, I would very gladly at my own cost and trouble, fit up what I believe to be a proper instrument and connect it to the gun, and will make it all ready for firing, so that there will be no difficulty about the matter. It is one of those subjects which I have taken a very deep and lively interest in, and having so far brought it forward, I should not like it to stop at the stage it has now arrived at. It is the practical utility of all these things that we must look to in the end. I know the hands of the Government are tied and trammelled very much in our country in doing things of this kind, perhaps more so than they ought to be, but as far as any assistance of mine can go, it is most completely at their disposal. My only object is to see the invention made a success, because I believe it would be an immense benefit to the country if carried into practical operation.

LECTURE.

Monday, December 15th, 1873.

FIELD MARSHAL H.R.H. THE DUKE OF CAMBRIDGE, K.G., &c.,
President of the Institution, in the Chair.

EXPERIENCE IN SAVAGE WARFARE.

By SIR SAMUEL WHITE BAKER, Pacha, M.A., F.R.S., F.R.G.S.,
Major-General of the Ottoman Empire.

YOUR Royal Highness and Gentlemen,—I feel it is somewhat presumptuous in me to offer any remarks upon military matters, not having had the professional education of a military man; but at the same time, I hope you will understand that I never sought this honour, it has been pressed upon me, and therefore I appear before you as a matter of duty.

To those who have studied the military art as a profession, it may appear a light matter to engage in war against savages armed with the rude weapons of barbarians, and furnished with fire-arms of the worst construction. The Officer who has been educated according to the rules that guide the movements of European troops, might regard with contempt an enemy wholly without education, whose forces, although numerous, are apparently devoid of organisation, and resemble at the first glance, the uncertain surging of a mob. Now, in my opinion, there cannot be a greater error in any commander than contempt of his enemy—savage though he may be. It is true that in an open country a handful of disciplined troops is superior to a host of badly-armed savages; but it must be remembered that the natives of a barbarous country possess advantages which in some measure compensate them for their inferiority of weapons, and the lack of what we call "military education."

The African savage possesses a thorough knowledge of his country. From his childhood he has run naked among the tangled forests and gigantic grasses, through which he can move with the ease and almost with the swiftness of a wild beast. Like the animals of his forest, he seeks covert at the first approach of danger, and the jungle, which to troops in uniform is almost impenetrable, is to the native warrior a retreat that shields him from all danger. Thus when the African is opposed to disciplined forces, he invariably relies upon the security afforded him by the difficulties of his country. His tactics

of attack and sudden retreat to his thick coverts, are exceedingly annoying to regular troops, who cannot overtake so active an enemy. There is seldom a chance of forcing him to fight upon a fair open field; thus the natives' actual loss in action is generally light, and he is accordingly ready to renew his sudden attack upon the first opportunity. Although not soldiers in our acceptation of the term, it must be remembered that every individual is a warrior. From earliest childhood, he has been in constant practice with the lance and bow. His barbed arrows, frequently poisoned, do fatal service at a distance of 120 yards. I have measured these distances, and practised the men at marks. The lance is thrown with great force and precision up to forty yards, and will fall into a body of men at sixty yards. Thus they can throw them into a stockade or fort at night. The common musket becomes formidable when loaded with slugs and used from ambuscades; and although all these savage weapons appear ridiculous when compared with modern inventions, it will be found that in the close and cautious fighting of the bush and grass jungles, these naked savages are not to be too carelessly estimated. It may be considered, as a rule, that native warfare is conducted upon the principle of "surprise," always allied with treachery. They will employ false guides or interpreters, who, having gained the confidence of their European enemy, will lead the troops into an ambuscade. Ever watchful, the natives spy out the movements of troops from the tops of trees in which their dark bodies are invisible in the thick foliage. Should a lack of discipline permit, stragglers will assuredly be cut off, or sentries be stolen upon, and killed by a lance or arrow in the back. The favourite method of attack in large force, is during the night, when the darkness reduces the danger from the fire of rifles. On such occasions, the natives generally halt, according to the conditions of the country, in forest or grass, about half a mile from the camp they propose to attack. Scouts are sent forward to ascertain the position of sentries, before the advance of the main body. The scouts being quite naked, crawl upon hands and knees until the darkness has permitted them to approach within a few yards of the sentries. They then lie flat upon their bellies, unobserved, until they can retreat to the expectant main body in the rear. According to circumstances, the attacking force now advances in perfect silence, and, approaching upon their hands and knees in the same manner as the scouts, they suddenly spring upon the sentries, and with wild yells, make a general rush upon the camp. This sudden attack would be extremely dangerous unless provided against; and in this manner they frequently surprise and massacre every one of a large party of slave hunters, and destroy their camp.

An Officer in command of European troops engaged in "savage warfare" should always beware of two great dangers, "treachery" and "surprise." The greatest care is necessary in patrolling, and the strictest discipline must be observed among the sentries. Upon no account whatever should natives (even if friendly) be permitted to enter your camp with arms in their hands. The weapons should be left always outside the camp in charge of a sentry before a native is

allowed entrance. A favourite mode of attack is thus treacherously to enter the camp armed, until by degrees a sufficient force has congregated, when at a given signal they rush upon the unsuspecting troops. I have known a whole party of slave traders killed in this way.

From this short description of the habits of Africans, it will be easily understood that bush-fighting must at all times be most unsatisfactory to regular troops. They will be harassed by fatiguing marches in a bad climate. Night attacks will constantly disturb their rest; men will be killed and wounded by unseen enemies in ambush, and there will not be the satisfaction of a fair stand-up fight in the open, to prove the superiority of the troops. From the experience of some years, I find that the best plan for carrying on a native war is to combine native tactics with the general manœuvres of regulars. The natives never expect that you will attack them on their own principles. Thus, ambuscades may be met with ambuscades, their positions may be carried before daybreak by a silent night march, and a sudden rush; and arrangements may be made for secretly occupying a large area by detached parties of riflemen in line so concealed in grass or bush, that the wily natives must inevitably fall into the snare when endeavouring either to reconnoitre or to attack the position.

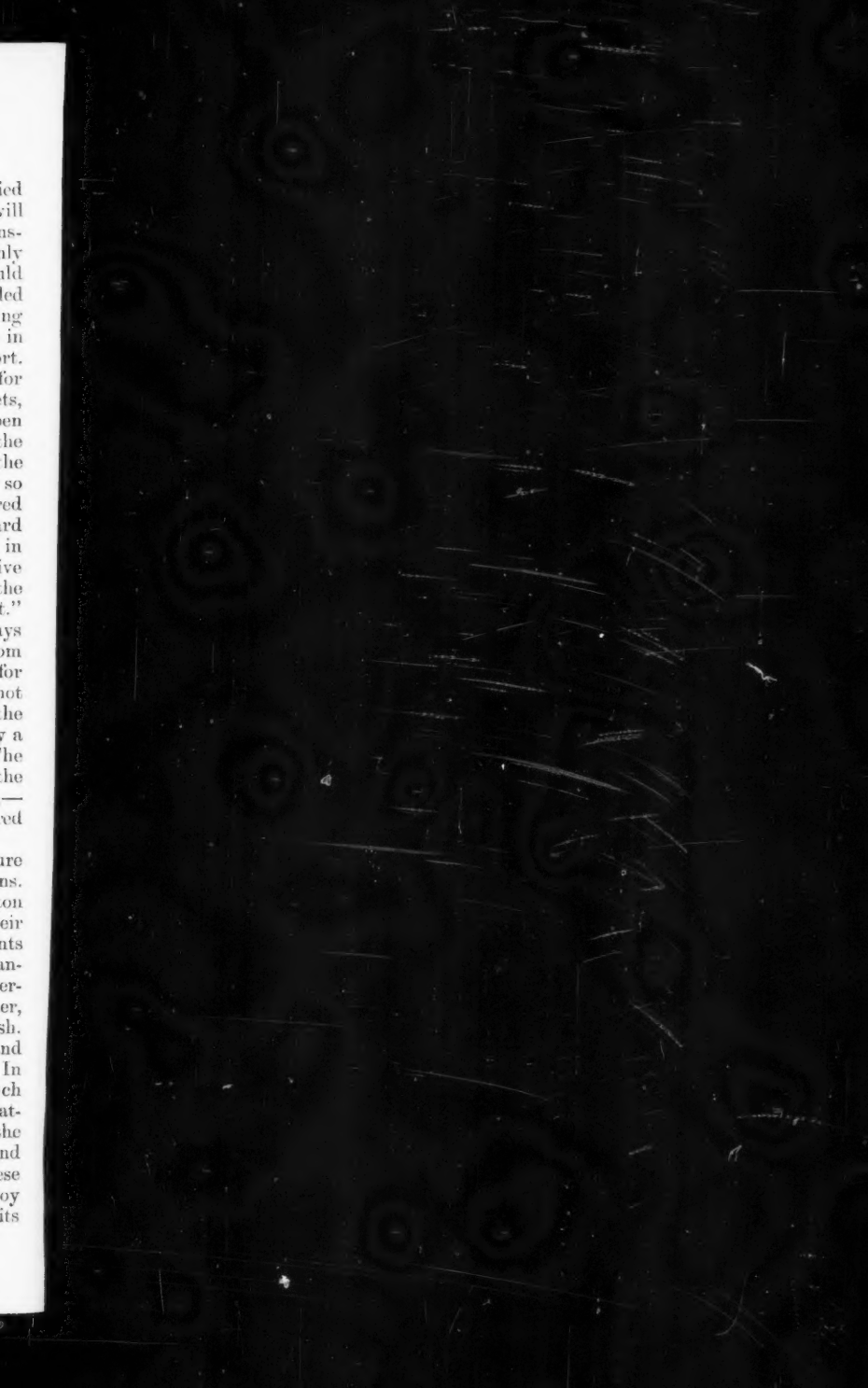
In commencing an African war, the first consideration is the outfit and the arms best adapted for bush-fighting.

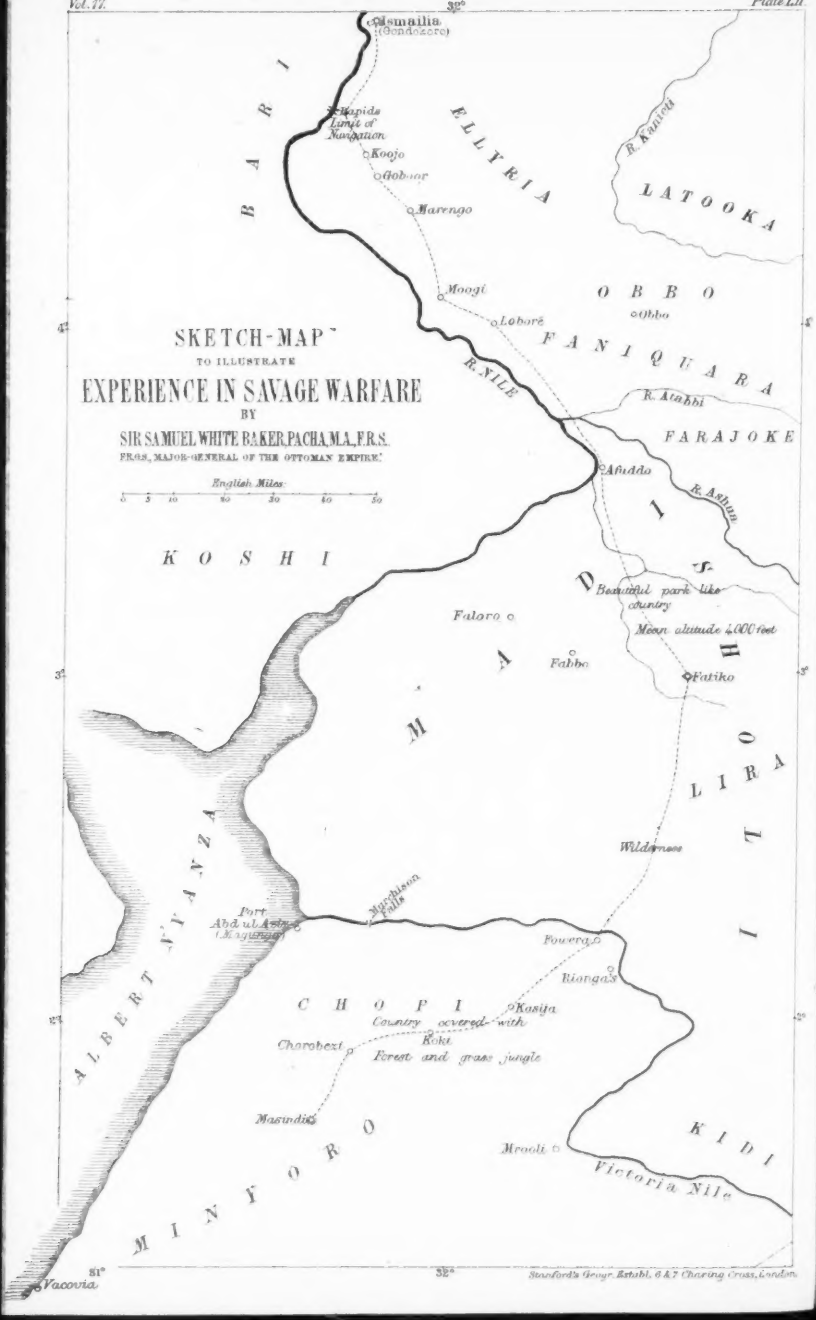
With few exceptions, long range rifles will have little practice, as the enemy will seldom show in the open. I should arm only one company in each regiment with rifles; the remaining companies should carry single barrelled breech-loader smooth bores of No. 10 calibre. The cartridge should be long enough to contain a charge of six drachms of powder with one No. 16 spherical bullet and twenty-four mould shot of the size known as S.S.G. A short sword-bayonet or broad bladed knife twelve inches in length of blade, should fix on this gun as upon the Government rifles. Now this knife should be strong and sharp, but without the cross guard, which is an unnecessary weight in the use of sword-bayonets. Such knives would be invaluable in camping out when it is necessary to clear away grass from a camp, or for cutting poles for huts, &c. Guns of the description I have named, would be far preferable to rifles for fighting in bush or grass jungles. The No. 16 bullet would travel through a long range, while the mould shot would be effective at 150 yards, and would sweep the enemy out of the covert with very fatal effect. It must be recollected that one volley from a company will throw about 2,200 shot and ball; this would be irresistible when delivered into masses of men. Should the regiment break covert and advance upon open ground, the rifle company would be thrown forward as skirmishers. When in jungle, the rifles would simply protect the rear. Rockets are invaluable, especially those known as Hale's three-pounders. These in reality weigh five pounds. In bush-fighting, the object of the rocket would be to try the jungle before the troops advanced. A forest or a prairie of high grass may conceal a large force of the enemy that would rush upon the troops when passing in single file along a narrow footpath, or attack them on flank and rear. A few rockets fired into the bush at a rather low

angle, so as to ricochet, while two or three were fired at a long range so as to explode beyond the enemy, would assuredly discover them, if concealed. A common native practice is to surround the troops with fire when marching in the high dry grass in the summer season. This is exceedingly dangerous should the wind be high, at which time the flames will travel at about six miles an hour. This I have also proved, because in American accounts of firing the prairie, there is no greater exaggeration than what is stated as to the speed at which the fire travels. We have seen pictures of cattle and horses galloping at full speed, and yet the fire overtaking them. It is perfect nonsense. I have walked before the fire in a high wind, and have also run before the fire in a fresh gale of wind, but I have never seen it travelling at a greater speed than six miles an hour. Therefore, if troops should be surrounded by fire, and do not lose their presence of mind, which men most likely will under such circumstances, there is plenty of time allowed for cutting down a little of the prairie grass in front, and setting fire to it in advance. If the grass is high enough to burn, on no pretext should troops enter it until cleared by the rockets, or set fire to by your own men. Upon such an occasion, should the enemy be concealed in the prairie, the grass may be set on fire far to windward by the rockets, and they would be placed in a difficult position. That dry grass question is a most serious one. I do not know whether in Ashantee country, the grass has the same character as the prairie in the centre of Africa, but if so, that must be recollected by whoever happens to be in command there, because a short time before I arrived at Fatiko, there had been a loss of every one of a slave trader's party. The natives set fire to the grass in one portion to attract the attention of the men. They were in ambush themselves, and out of 103 men composing the slave hunting party, not one man escaped. At the same time that I acknowledge the extreme importance of Hale's rockets, I must express my astonishment and disappointment, that projectiles so admirably adapted by their portability for savage warfare, should be rendered almost useless by the absence of explosion. A rocket weighing five pounds (*i.e.*, the so-called three-pounder) can be slipped under the strap of a soldier's knapsack and carried with ease during a march, so that without extra transport, the projectile is at immediate hand. It is invaluable when the troops are making a night attack, for as they have to be under arms at midnight, and to march 12 or 16 miles by daylight, in such circumstances it is most cumbersome to employ native carriers, and also very uncertain, because they are extremely likely to bolt. This rocket should explode with a bursting charge of an ounce of strong powder. Upon bursting, it should scatter inextinguishable fire-balls that would burn for a minute. This arrangement would produce the *ne plus ultra* of projectiles for bush-fighting. Two or three rockets would suffice to shell out a stockade, as the thatched houses would be immediately ignited, and the heat would compel the enemy to evacuate the position. I used Hale's rockets throughout the Bari war, but in no instance did they ignite the thatched huts. Upon several occasions they passed through the grass roofs, but the rapidity of their flight did not afford sufficient time for ignition, as the rocket can only depend upon its

back fire. This is an important defect that can easily be remedied by the application of the explosive system proposed. Field guns will be of little service in the bush, owing to the great difficulty of transport. Explosive rockets would be much more serviceable. The only use for the guns will be for the defence of stations, where they would be used with case shot. I had ten guns in my late expedition,—rifled bronze barrels weighing 230 lbs. each, to carry shell of 8¼ lbs. Having no means of transport, I found them simply a useless incumbrance in marching, and they were quickly condemned to inaction in the fort. The result of my experience would lead me to condemn as useless for the actual bush-march, any other weapons except explosive rockets, powerful breech-loading smooth-bores for buckshot, and rifles for open country. There should be another important addition to the outfit of the troops. Every man should carry on the top of his knapsack, under the straps, a small but strong axe. This should be of a rather soft steel, so that it can be easily sharpened on a stone or with a file. Hard-tempered steel will chip, and the axe will soon be rendered useless by the hard woods of tropical countries. The success of an expedition depends in a great measure on the health of the troops. Nothing is so conducive to this as the possession of a handy little axe by each man. When the halt is sounded, the first order should be "build huts for the night." In the rainy season, or should the weather be doubtful, it will always be advisable to finish the day's journey in one march. Thus, from 6 A.M. to 11, the men will march 14 miles, which is quite sufficient for them if they have to march every day. In an enemy's country not only have the men to build huts, but it will be necessary to protect the camp by a strong fence of thorns, so that it cannot be stormed by a sudden rush during the night. The axes at once come into play. The sword-bayonets, kept well sharpened, are most useful in clearing the high grass from the neighbourhood. This serves a double purpose,—roofs for the huts and bedding for the men, while the ground is cleared for the sentries.

My men were for the most part blacks; thus they could endure fatigue and exposure that would have been trying to Europeans. Their kit consisted of a scarlet flannel shirt, white Zouave cotton trousers, gaiters, and sandals.. They carried a spare suit in their knapsacks, together with a blanket, but no great coat. No tents were carried on the march except one for myself, which I abandoned for want of transport, and contented myself with a few waterproof camp sheets. We thus travelled in light marching order, which I strongly recommend if fighting is contemplated in the bush. No one can conceive the advantage of being free from the trouble and delay of packing heavy baggage when starting before daybreak. In every bush-country, silence must be rigidly enforced during the march in time of war. A multiplicity of baggage is sure to occasion chattering and noise among the carriers, which may give the alarm to the enemy when a secret march is essential to success. Secrecy and rapidity of movement are the first elements of bush warfare. In these qualities the African natives excel. It is therefore necessary to employ spies, and to keep in pay, if possible, some of those discontented spirits




Ismailia
(Gondokoro)
Rapids
Limit of
Navigation
Koojo
Gobsior
Marengo
BARI
ELLYRIA
R. Kaaiad
LATOOKA
Moogi
OBBO
Obbo
Laboré
FANIQUARA
R. NILE
R. Atabbi
FARAJOKE
Afudda
R. Ashua
KOSHI
Beautiful park like country
Mean altitude 4,000 feet
Faloro
Fabbo
Fatiko
MADI
LIRA
HILLS
Wilderness
Port
Abd ul Aziz
(Magungo)
Murchison
Falls
ALBERT N'YANZA
Fowera
Riongas
CHOPI
Kasija
Country covered with
Roki
Forest and grass jungle
Charobezi
Masundi
MINYORO
Mrooli
KIDI
Victoria Nile
Vacovia
SKETCH-MAP
TO ILLUSTRATE
EXPERIENCE IN SAVAGE WARFARE
BY
SIR SAMUEL WHITE BAKER PACHA, M.A., F.R.S.
F.R.G.S., MAJOR-GENERAL OF THE OTTOMAN EMPIRE.
English Miles
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that are to be found in all countries, who, having quarrelled with their own people, are eager to turn against them. These men must keep the commanding Officer (and him only) informed of the intentions and movements of the enemy. It is essential in all countries in bush-fighting to make certain that you can get spies that you can depend upon, because these people are so treacherous and so exceedingly clever that they will engage as spies but simply to spy *you*, and of course they lead you into all sorts of difficulties.

When the Khedive's expedition first reached Gondokoro, N. lat. 4° 54', the military force consisted of 1,200 men. The troops were occupied in building the station and in erecting iron magazines for the innumerable stores, &c., at the time when the Bari war broke out. This powerful tribe, having been incited by the slave-hunters to resist the Government, commenced war. The country resembled a well-timbered park bordered by the river Nile, and diversified by mountains about eight miles distant. The forests in the neighbourhood were particularly beautiful. There was one forest in which you could ride for about an hour, composed almost exclusively of magnificent tamarind trees; in fact, nothing can exceed the beauty of the whole country.

The Baris are a very active and warlike people, numbering, I should imagine, about a million and a half. Although these people had lately been at war with a powerful tribe about three days' march east of Gondokoro, they concluded not only peace, but an alliance with their late enemies, for the express purpose of making a joint attack upon the Government station. At that time the troops were so engaged in erecting shelter for themselves and for the stores, that no regular defence had been commenced. The only protection for the station, was a fence of thorns, simply boughs laid upon the ground, one upon the other with the stems inwards. I had a separate station a mile and a half distant upon the bank of the river occupied by the corps of 48 Snider rifles, which formed my body guard. These men were selected from the two regiments which formed my force, and I had taken much pains in teaching them the use of the rifles. This little *corps d'élite* was a great exception, both in discipline and intelligence, to the main body of the expedition, and I owe not only my success, but the actual existence of our party, to their superior arms and organization. I take this opportunity of saying, I think that even among savages, although at first you may be disappointed by their obtuseness, and in fact by the extremely low level of their intelligence, after a little time, you may improve their *morale* by setting them a high example, and by establishing in fact a sort of code of honour, which though at first they do not understand, yet an *esprit de corps* will be the favourable result. I picked out these men from the 1,200, and if a man showed some inferiority he was drafted out again and another man substituted. If a man was a thief, I used to call the men together, and not only did I punish him, but I gave them a lecture upon the disgrace of thieving in the character of a soldier. At last I established such a praiseworthy *esprit de corps* among them, that they would have gone through fire and water for me; and if by vacancy or death, it was neces-

sary to replace a man, if the character of the man selected was not wholly known as honest, the others would not accept him; they would say, "He won't do for us, he will only do for the regiment; you cannot depend upon him, he is light-fingered," and so on. This was a most satisfactory result.

My station at that time was merely a very pretty garden by the side of the river. I had hardly commenced a fort; but I had a few huts with my "forty thieves," as I used to call my *corps d'élite* in the neighbourhood. No open hostilities had commenced, and I had no idea of an intended attack. At about two in the morning, I was awakened by the sound of shots fired at head quarters 1½ miles distant. This was followed by the yells of an untold body of natives, who had simultaneously attacked the camp. The bugles sounded the alarm, and in a short time a heavy file firing told that the attack was general. My few men fell into position, but I could, of course, do no more than hold my station, momentarily expecting an attack upon our weak party. It was a strange thing that the natives had devoted themselves to the attack of the chief station garrisoned by upwards of 1,100 men, instead of attempting an assault upon my little post, but I suppose they were expecting to get hold of the ammunition. In about half an hour the affair was over, and the enemy was repulsed with the loss to us of one corporal killed and some soldiers wounded by arrows. In this attack the native scouts had been challenged and fired at by the sentries. They had then used peculiar tactics. At a distance of about half a mile they rang bells, beat their drums, and blew their large horns so as to deceive the troops, with the idea that they were at a great distance from the station; but in reality their main body was stealthily advancing in the darkness, while the drums and horns were sounding in the distance, until they suddenly rushed unexpectedly upon the station. The protection of thorns served to check the assault until the heavy fire of the garrison repulsed them. This attack was the signal for general hostilities throughout the country, and I established patrols by day and night, in addition to the usual sentries. In spite of this, we were subject to continual disturbance; every night the sentries fired upon scouts who were discovered approaching in the stealthy manner already described. I set all hands to work to entrench the camp, and at the same time made a triangular fort at my private station. The ditches and earthworks were completed in about three weeks, and guns placed upon the bastions. During this time, we had been as usual annoyed by the natives, more or less, every night, until I arranged a plan which put a stop to their attempts. The plan was simple and very effective. I posted small parties, consisting of five men each, in convenient positions, such as behind the massive hillocks raised by the white ants, or behind a thick solitary bush. These parties were thoroughly concealed at a distance outside the usual beat of the patrol, and every approach to the station was thus guarded. I felt sure that the enemy would fall into the trap, as they would as usual attempt to reconnoitre, but would have no suspicion of such ambuscades outside the patrol. For this night-work I changed the arms, and for the Snider rifle, so invaluable by day, I substituted muskets, with each a

cartridge of eight buck shot, rammed down above the ball. Nothing could be more successful. As I had expected, the natives came unawares upon the guards thus concealed. Every night the positions were changed, and thus it was impossible for the enemy to know the points of danger. Several of them were shot; one was captured alive and hung on the following morning on a tree as a warning to the rest, and in a short time the nights were so entirely undisturbed that not one native dared visit the camp. The forts were finished, the magazines were erected, and the entire material of the expedition was under shelter. There was no possibility of an attack upon so strongly fortified a position. I accordingly started with a force of 450 men to punish the Baris who had imagined that we were afraid to enter the interior. The first point of attack was the country of Belinian, about twelve miles distant. These people had been the worst among our enemies. They had murdered several sentries. In fact, sometimes the Baris appear to have quite as much cunning and audacity as North American Indians in stealing upon the sentries and murdering them before they had the least idea of their neighbourhood. The country was exceedingly beautiful, being a mixture of forests, mountains, and plains; the latter being cultivated to a large extent with dhurra (*Sorghum vulgare*), which grew to the height of about 9 feet. There were five or six hundred villages throughout this populous country. The natives had formerly succeeded in destroying some slave-hunting parties; thus they were possessed of more than a hundred guns and a considerable stock of ammunition. The Sniders very quickly produced an impression. The natives opened fire from their stockades, which were taken and forced at the bayonet by my troops with the loss of only one man and one woman wounded by bullets. It appears extraordinary that the women should come into action, but the fact is, that they followed close up to the troops with provisions.

After a few days of sharp experience, the natives took to their mountains and forests, in which they concealed their cattle. I determined thoroughly to explore the bush, which, although dense in some places, would usually allow an advance in skirmishing order. I venture to suggest that an advance through the bush should be conducted by three lines of skirmishers, each distant about twenty yards, while the skirmishers forming the first line should be only a man's length apart. An advance in this open formation with three companies, will cover about 200 yards in length. The rear rank forms a protection, while the second line will act as support, either for the first line, or, should the rear be attacked, they can face about and support it in turn. I succeeded effectually in driving the enemy from their forest hiding-places, and in capturing both corn and cattle. This was accomplished with the loss of very few men on our side. I do not think more than five or six were killed; this included the murder of a Turkish Major who had been through the Crimean War, but lost his life by losing his road through a breach of discipline, and fell into the hands of the enemy, who show no mercy. Upon my return to head-quarters after thirty-two days, I found it necessary to commence operations on the west bank of

the river. This was beautiful open ground, and afforded an opportunity of trying the Arab horses, twenty-one of which I had brought with me from Cairo. Wherever the *country will admit* of cavalry operations, this arm should be employed against savages. In the portions of Africa that I have visited, the natives have an extraordinary fear of horses, which to them are strange, and supposed to be dangerous animals. I have frequently charged with only four or five horsemen, captured herds of cattle, and put to flight large numbers of the enemy, whom I have held in check until the arrival of the infantry. Unfortunately, I lost nearly all my horses by an epidemic, and at the close of the expedition only three remained. Such losses should not deter either a Government or a traveller from employing horses. They are invaluable, and when used up, they will have more than earned their cost and the expenses of their transport.

The Bari campaign that had been carried through on the east of the Nile had so far raised the prestige of the Snider company, that their appearance on the west was sufficient to over-awe the country which was almost devoid of forest, and accordingly no covert existed for the enemy. For an immense distance, the landscape afforded a perfect field for military operations. The grass having been fed close by innumerable cattle, exhibited a clean surface upon long rolling undulations that drained from the distant mountain chain to the Nile. Each ravine between the waves of high ground was, in the wet season, a roaring torrent, but was, in the dry season merely a deep bed choked with rocks. The whole of this country was thickly populated. I advanced south in eight vessels, the troops marching on the banks of the river. I had only 250 men, as the Egyptian regiment had returned to Khartoum, some sick, but all dissatisfied on account of my suppression of the slave trade. The black troops were well adapted for the rough and constant work required. Many of the Officers and men had served under Bazaine for some years in Mexico, and they, and in fact all, were far superior in *esprit* to the Egyptian Arab regiment. The Snider company had hitherto been distinguished by scarlet flannel shirts, and so great was their reputation, that the sight of a red blouse was enough to create dismay among the natives. I now dressed all my men in scarlet and proceeded to the south, intending to push on towards the Equator to annex the country, and to purge the new territory from the slave-hunters, who numbered about 1,100 men in the southern districts. These were mostly Arabs of the Soudan, together with many black soldiers who had deserted from their regiments at Khartoum and settled as pirates in the employ of a firm (Agād and Co.). This firm employed about 2,500 such ruffians as slave-hunters in Central Africa. These men were organised as irregular troops armed with muskets, rifles, and double-barrelled guns, and were officered in imitation of the Government regiments. All were Mohammedans. The slave-hunters had endeavoured to incite the natives against the Government throughout all these countries. In some they were successful.

My vessels arrived at N. lat. 4° 38′. This is the limit of navigation on the White Nile at the foot of the last cataracts. It was impossible

to make friends with the natives, all of whom were Baris. A great chief pretended friendship, but his people attacked the guards at night and attempted to carry off the cattle. Fortunately, I had taken every precaution, and the enemy was repulsed. It was quite impossible to proceed, as I was without either carriers or transport animals. Having a good knowledge of the country, I left 150 men in charge of the vessels, and, with a hundred men, I started for the country of Loboré beyond the Bari frontier. There I proposed to hire carriers, who, with an escort of troops would return and bring up the baggage from the vessels, which would then return to Gondokoro. From that point (lat. 4° 38′) the entire expedition for the annexation of Central Africa and the suppression of the slave trade would be composed of only 212 picked troops, including Officers, buglers, drummers, &c. I was well aware that, should I fail, I should be blamed by all military authorities, as I had a march before me of about 350 miles without the power of forming posts of communication. Thus I should be cut off from my base. I knew also that the slave traders were against us, although at that time I did not expect open hostilities from them. By the departure of the Egyptian regiment, my entire force was reduced to 502 Officers and men. I had therefore to determine upon action with great risks, or inaction at headquarters. The latter would have played the game of the slave-hunters, and the expedition would have been a failure. I fully expected that after my departure with a hundred men for Loboré, the natives would attack the Officer and the weakened detachment in charge of the vessels and baggage. I therefore drew the vessels in close line along the bank from the mouth of a broad and deep but dry ravine, which ran at right angles with the river. The south flank was thus protected; the west was the broad Nile (about 400 yards in width). We were only exposed on two points—the east face and the north flank. I placed a six-pounder gun in position on the east face, which commanded every approach, as the country, though undulating, was perfectly clear. My instructions before leaving the Officer in command were as follows: at sunset, all cattle (about 2,000) to be secured in the bottom of the ravine close to the river. A sergeant's party to line each side of the ravine as cattle guards. These men would in case of an attack on the east face enfilade the enemy, who would be exposed to a cross-fire in addition to that of the gun. The gun to be loaded at sunset with a canister containing 250 musket balls. The tube to be placed in the vent with the lanyard attached. The gun to be sighted for 200 yards, and to be covered with a raw hide to protect it from the heavy dew. I served out some new English tubes, as those supplied by the Egyptian Government were very uncertain. I left all vessels and men with the above precautions.

Many people may imagine from what I have done, that there could be no great difficulty with the natives; but unfortunately I have always found that whenever I have sent an Officer in command of troops with certain orders, they invariably met with calamity, if not defeat, through the carelessness of the Officer in command. I reached Loboré in four days, through a most populous country,

without firing a shot. I engaged 500 carriers which I sent to the vessels with an escort of 50 men. In the meantime a general attack in great force had been made upon the vessels. It was a rule without exception, that if I left an Officer with a certain duty to perform, it was neglected. The sentries were for the most part asleep. The gun was not even loaded. The good English tubes had been put away so carefully that they could not be found. The natives attacked in the dead of night. They surprised and drove in the guard upon the east face, who took refuge in the vessels. The artillerymen deserted the unloaded gun. One man was killed upon his piece in his vain attempt to load it. A woman was killed in a boat by a spear. Fire was thrown into the vessels. The six-pounder gun was actually in the hands of the enemy, but they did not know how to carry it off. This attack would have ended in the destruction of the party and the vessels and material had it not been for the flanking fire from the cattle guards posted along the edge of the ravine. This created confusion, and killed and wounded many of the attacking party. The soldiers in the vessels having recovered from their first surprise, poured a heavy fire into the front and took the gun. The artillerymen in their haste loaded the gun with shell instead of canister, and even then they could not fire it, as tube after tube failed, in the absence of the good Woolwich tubes. However, after all this disgraceful mismanagement, the enemy were repulsed. This little incident serves to show how much depends upon the Officer in command, even when regular troops are opposed to savages. There is no quarter given in such warfare. A victory gained by the savages implies the massacre of every one of their opponents.

My men arrived safely at Loboré, numbering 212, including Officers. The vessels returned to Gondokoro. We were now fairly started, and were out of the Bari country. Every native was a friend, as I was well known to them on my former visit. I arrived at Fatiko, N. lat. 3°01', a distance by route of 161 miles from Gondokoro. No one can conceive a more beautiful country. The climate is comparatively cool. The mean altitude of the land is 4,000 feet above the sea level, and the landscape is a vast park laid out by nature with a combination of rocky hills, magnificent timber, fertile valleys, clear streams never more than a mile apart, rippling over the acacia shaded rocks, and distant mountains closing in the horizon. In this paradise the slave-hunters had established the most perfect hell. They not only occupied Fatiko by a large station, but they possessed a chain of four well-chosen positions, each about 22 miles apart, which, being garrisoned by about 1,100 men, dominated the entire country. Now these people whenever they attack a country, always do it by treachery. They are generally well received by the natives, who make them presents of cattle, and even of young girls, &c.; but after they have established thorough confidence, they will get up at midnight and make a treacherous attack upon the villages; they set fire to everything, murder all the old women—(because, being old, they are impossible to sell in that country)—likewise the small children, and in this way they utterly destroy a beautiful country.

I was well known to the natives of Fatiko in my former journey. The chiefs quickly assembled and claimed the protection of the Government, declared their allegiance, and recounted the horrors and reckless massacres committed by the slave-hunters throughout the country. I at once gave them protection; and as Governor-General of the country, I gave the slave-hunters written notice to leave the country and to return to Khartoum by a given time. At the same time I offered them the option of enlisting in the Government service to form an irregular corps. I left at Fatiko a detachment of 100 men with the heavy baggage, and the greater portion of the ammunition under the command of a major, and started with 112 men for the capital of Unyoro (Masindi), a distance of 160 miles south of Fatiko, within a long day's march of the east bank of the Albert Nyanza. It is impossible to see the Albert Nyanza from that position, but with a telescope you can see the waterfalls pouring down from the mountains on the lake, therefore I concluded the west shore was about 50 miles distant. In the short space of a lecture on "Experience in Savage Warfare," I cannot venture into the details of the intrigues and difficulties which terminated in a rupture with the King of Unyoro. I had hoisted the Ottoman flag, and formally annexed the country, with the understanding that the King was to represent the Government. We were apparently the best friends, and he begged me to send to Fatiko to recall the Officer in command together with all troops and material, so as to concentrate my force at his capital, Masindi (N. lat. 1° 45'). With the treachery usual among his race, he had laid a deep plan to massacre the whole party, and to possess himself of the arms and ammunition, together with all the effects of the expedition. I wished to concentrate my force at Masindi, believing in the good faith of the King and his people. I therefore sent a sergeant and ten men with letters, together with twenty-five men who had enlisted as irregulars, thus forming an armed party of thirty-six men, accompanied by three hundred natives as carriers, who were to convey the effects from Fatiko, in charge of Major Abdullah and his detachment of 100 men. He was an Officer whom I trusted, as he had been in Mexico under Bazaine for some years. In reality it was intended that the 300 natives were to carry the effects and to gain the confidence of the troops; but when near Unyoro, the unsuspecting soldiers were to be murdered while asleep. In the meantime, I and my little force of 100 men were to be poisoned and got rid of as speedily as possible. My men left with the post for Fatiko on 23rd May, 1872.

Although the natives of Unyoro are inferior to the Baris as warriors, they are far more dangerous, as that extensive country is thoroughly organized. The King has a large body of troops continually about him, including a body guard of about fifty men armed with muskets. Every district is under the government of a Chief, who is personally responsible for the acts of his people, all of whom must rush to arms upon the beating of his war-drum. Thus, in case of war, every Chief of a district arrives at the head-quarters with an army, an army called suddenly by the war-drum, and it is most extraordinary to see the celerity with which these people collect. Thus it would be

impossible to guess even the approximate number of warriors that could be raised in Unyoro at the King's command. The extent of Unyoro is about 160 geographical miles in length and 70 in width. Some natives are armed with bows and poisoned arrows, some with spears, and a few with guns.

After the departure of my men for Fatiko a change in the manner of the King and some of his principal Chiefs determined me to build a small fort for the protection of my ammunition, &c., in case of need. My men worked with great alacrity, and as the timber was close at hand I completed in a few days a circular stockade of thick trunks of trees buried 2½ feet in the ground. It was my intention to surround this with a deep ditch, the earth of which, thrown against the stockade, would have rendered the crevices ball-proof. I believe the erection of this little fort hastened the attack, as the guilty King suspected that I had gained information of his treachery. There were about 8,000 armed men in Masindi, but few women. The absence of women is a sign of distrust and suspicion in savage countries. If you go to any country and the women and children come to see you, or are seen running about without any suspicion, there is no fear of hostility; but if you do not see the women, you may depend upon the necessity for keeping a strict guard. The capital town, Masindi, consisted of several thousand houses, built, as is usual in that country, of canes and straw, resembling huge bee-hives. My station was adjoining the town, entered by a broad gravelled approach, like a carriage drive. On the evening of the 7th June, an attempt was made to poison myself and the troops. It had been the custom of the King on many occasions to present me with plantain cider in large quantities. On this occasion seven jars were brought, five of which were served out. The force of the poison was so immediate, that a warning was given to the men before all had time to drink, for about forty were in a state of delirium and insensibility. I administered strong emetics and shut up the sick within the fort. I turned out the remaining sixty men, who kept guard throughout the night. On the following morning, at 5 o'clock, I inspected the sick within the fort; they were much better, and I sent them to their quarters. I sent a Lieutenant and a corporal to beg the Sheik to come and examine the cider that remained in the jars. The Sheik's house was about 200 yards distant. I was walking up and down the approach smoking a pipe and expecting the return of my messengers. A bugler and a sergeant were behind me; thick castor-oil shrubs bordered either side of the approach. Suddenly I was startled by the savage yells of crowds in the direction taken by my messengers, and two rifle shots in quick succession were the reply. The bugler, by my order, sounded the alarm. At the same moment a hot fire opened upon me and upon the Government House from sharpshooters concealed in the castor-oil shrubs within a few feet of me. The sergeant at my side fell shot through the heart, another man quickly fell shot through the lungs, and another was shot through the leg. The fire being exceedingly hot, was replied to with very great alacrity by the troops. The men had had so much fighting for some years that they could be thoroughly depended upon,

and the moment they heard the bugle they formed a square, in very open order sufficient to protect a couple of acres of ground. It was done instantly; but had not the bugler been at hand, we should have been overwhelmed, for hardly had I my rifle in my hand and my belt fastened, when there was a rush of about 8,000 men upon the station. When that first rush was made, it was extraordinary to see how impossible it appeared for natives in masses to produce any effect against Snider rifles. They were cut down in the high grass in all directions.

One thing which is very necessary in African warfare or travelling, and I think in the Ashantee war we ought to have them, is a good supply of blue lights (capped blue lights), that you can immediately strike upon the butt end of your gun. Luckily for me I had plenty, and the first order I gave was for two parties to advance on each flank to set fire to the town to the right and left under the protection of the Sniders. A blue light will set fire to a grass hut in an instant, but a hut is a very difficult thing to set fire to with a fire-stick; you have to blow the fire with a bit of grass on the top, and meanwhile you may have a lance or a bullet through you. These two parties with blue lights set fire to the town to the right and left; a strong breeze luckily was blowing from us, and in a few minutes there was a roaring sheet of fire. This protected both our flanks; so I immediately gave an order to the sixteen Sniders to advance into the heart of the town, protected by the fire on the flanks accompanied by men with blue lights, who fired every house as they passed. There were not more than 100 of my men, and there were certainly 7,000 or 8,000 of the natives, about 50 armed with guns, and all organized to a certain extent by having a Chief to each regiment; but in the course of an hour and a half, not only was the enemy entirely defeated with great loss, but every single house was destroyed by fire, and the battle was won.

This was a very awkward position, which all military men will appreciate. I was 330 miles from head-quarters. I had already sent 300 carriers to Fatiko who I knew were traitors. Now the veil was lifted, and these 300 men would murder my 100 men that I had written for; therefore I should lose my little force with the whole of my ammunition, and in fact it would be utter destruction. Nobody knew the way—there was no road—the country was covered with forest and grass jungle; it was the middle of the rainy season, and in fact it was the most difficult time that I ever had experienced. I knew perfectly well what to do, but the great difficulty was, how to do it. I had a mass of luggage of all sorts without one man to carry it; I had a quantity of ammunition, but who was to move it? Every day's delay would raise additional thousands against us, and I knew that the King,—who had run away at the commencement of the fight,—would stop the road, and orders would be sent immediately, so that we should have to fight every inch of our way with only one hundred men, carrying loads through this infernal jungle. However, I made up my mind, and called my men together. Now these fellows who were so undisciplined at first, had really become so thoroughly disciplined by the example of the Snider corps, that it was only necessary for me to give an order—they placed such entire confidence in me after having

gone through so many difficulties with me and having got out of those difficulties with so little loss, that it was only necessary to give an order and they instantly obeyed it. I called the men together and spoke to them. I said, "we are in a dilemma, but you have often been in dilem- "mas with me, and we have always got out. Now is the time for you "to show whether you are men or not. It was only a day or two ago "in the battle of Masindi that you, one hundred, beat something like "eight thousand. Now you will have to fight every day. You will "have to march through grass that we came through some months "ago, now it is ten feet high, but then it was only up to your breast, "and you will have to fight every inch of the road. Every man will "carry a load; we must have merchandise to pay our way with "when we arrive at the river." You must have money of some sort in Africa. I arranged the march in this way. The advance guard was led by a most excellent Officer, Colonel Abd-el-Kadir, with sixteen Sniders; they carried no luggage, and he, of course, had a bugler. I came next, in charge of all the ammunition, with Lieutenant J. A. Baker, R.N., and Lady Baker close behind me and my servants, and ten Sniders and a bugler. The rear guard was commanded by a Captain with 16 Sniders, all admirable men, and the few Sniders that were left afterwards were interspersed along the line armed only with muskets. I made an arrangement with my men, "In case you are "attacked by an ambush on both sides of the line, every alternate man "is to face right and left," so that they could open a line of fire to right and left immediately. The men were a little nervous the first two days, and they had reason to be. We were attacked by enormous forces, and how it was that they did not overwhelm us I cannot tell, except that they were so thick together that the bullets must have taken frightful effect in the high grass. Moreover, there happened to be some double-barrelled breech-loading elephant rifles which carried eight drachms of powder and a picrate of potash shell, which would leave very little of a man if it exploded on him. It also made a hideous noise, the report of the shell being rather more than the report of a rifle. I always noticed in a hot attack when the lances were flying about in the most unpleasant manner, that whenever these picrate of potash shells were fired, some great effect was produced. We had to fight in this way, marching 14, 16 or 10 miles a day, sometimes through swamps, always through this fearful grass. We had to fight for seven days from morning to night, never seeing the enemy, but all through ambuscades. The difficulty was to convey the wounded. There were only two horses, which were loaded like camels with luggage. My wife had to march on foot during the whole of the work. There was only one donkey which was a spare animal, he was carrying a wounded man, and still I am happy to say I got through and never left one wounded man in the hands of the enemy. I am quite sure if it had not been for the discipline of those troops, no force of that small number could possibly have got through; but they observed a most admirable discipline from the commencement of the march to the end. Although it was impossible to see more than five men in front and an equal number behind, on account of the high grass, still of course we kept

up communication by bugles. If it had not been for the bugle in the rear which always sounded "halt" when a man was wounded or perhaps some woman was tired or had to shift a load, our line would have been cut, and if so, there would have been an end to everything. At all events I got my men through. I made an alliance with a very powerful chief and left sixty men with him. He quickly drove the whole of the enemy out of the country. The Sheik Rionga now reigns as representative of the Government.

I was anxious to find out where the unfortunate Major Abdullah, with his hundred men who were to have been massacred in the grass, were, and I determined to take my "forty thieves" and to leave the sixty men with my new ally. I determined therefore immediately to push back to Fatiko, and see what had become of Major Abdullah and my detachment. I started, and having crossed the Nile, I met men who had been sent by the chief of the country to implore me to come immediately, for the whole of the slave-traders had intrigued against me. They had heard that I had been massacred. These slave-traders therefore intended to collect together to attack the hundred men under Major Abdullah, to massacre them, to take all the ammunition and effects, and to spread the reports (which came to England) that we were "already murdered "by the natives." We marched as fast as we could, and passed through 78 miles of wilderness. When I arrived within ten miles of my station in this lovely paradise, Fatiko, I came to a village where the natives had collected, having heard of my intended arrival. The chiefs laid their case before me. They said, "If you are a Government "why do not you protect us. You offered us protection, and "we have sworn allegiance, but you have only left one hundred "men to represent you, and we are pillaged and murdered by 1,100. "Now we believe in you still, but show us your power to protect "us." On the following morning I started early, and when I arrived at Fatiko I was like one risen from the dead. I found the detachment there; for the King's arrangement to murder them had failed; they had only killed eleven of my men on the march. Instead of keeping quiet and carrying out the King's orders, they got into a squabble with my men, and the plot broke down before the appointed time. I found the major with his detachment and all the *matériel* quite safe. No sooner had we embraced, than a withering volley was opened upon us from these scoundrels of slave-traders, who were in camp 270 strong, no more than 90 yards distant. Seven men were knocked down immediately, and we should have lost a large number, as the men, being dressed in scarlet, were a fair mark, and closely packed together. However, my "forty thieves" were not pleasant people to fight with; and the instant the attack commenced, it was only necessary to sound the advance with the bayonet, when the forty, leading the charge, broke up the 270 rebels, and in fact crushed them at once. In rebellions, I do not like hanging people after the fight is over; but at the same time, when troops are called out to act, I think it is as well to let them act thoroughly, and not to sound the bugle to "cease firing" until a severe lesson has been given. I was determined, as this rebellion had commenced, that the bugle should be

perfectly silent until I should sound "the assembly," and therefore the fight continued. Out of 270, 141 were left dead upon the field, and 43 were captured as prisoners, 306 cattle were taken, and a number of donkeys, the latter being a most valuable prize. This was a very fortunate affair, because it almost terminated the expedition. It raised the Government troops in the eyes of the natives, and drew them towards the Government at once; and from that moment I really had very little difficulty. If I had wanted 50,000 men I only had to hold up my hand. I arranged with them that they should not attack the other slave-traders, but I so managed that I formed an irregular corps of 300 of the best of these people, and drove the rebels entirely out of the country. Some of the slaver chiefs were shot during that action, and altogether it was a victory, not only physical but moral. The whole country was at peace, and the delightful reward was, that after so many difficulties, it was not only peace, but perfect prosperity. I established a corn tax, and the natives paid it with the greatest good will. When I left, they were cultivating an immense country.

To show the difference of command, I had sent for reinforcements to Gondokoro, 160 miles distant. 300 men were coming up to me as reinforcements through a country which I had passed through without firing a shot. The *morale* of my men was perfect, but these 300 new men, during their march with an Egyptian Colonel, actually got into a row with the natives on the road, were defeated, and lost thirty men killed, and all their arms and ammunition taken; thus all the good work that I had done, appeared to be destroyed. When I returned, I fully expected to have had to fight my way back; but the natives never attacked me. I marched through the country, as I would march through London, in fact without being jostled.

Throughout the late expedition I have been ably assisted by Lieut. J. A. Baker, R.N., who has upon all occasions upheld the reputation of the noble service to which he belongs.

Your Royal Highness, I have already trespassed too much upon the time usually permitted, but having given this simple and short description of some incidents that have happened, believe me, I do it without the slightest presumption, trusting that out of so much *débris* of matter, those who are practical, and belong to the military profession, may perhaps find one or two grains worth collecting.

The CHAIRMAN: Sir Samuel Baker and gentlemen, I am sure that I am expressing the sentiments of this large and important meeting when I say, that we highly appreciate the very able manner in which you have brought to our notice in a very short period so many interesting details in connection with the duties upon which you have been engaged. There is nobody in this room, there is nobody in this country who does not rejoice to see you amongst us once again, and able to give us an account of the very extraordinary power which one man has had over such vast hordes, all of whom, as far as I can make out, were originally disposed to take anything but a favourable view of the leader sent amongst them. Now, gentlemen, there is one point in all this which I think gives us great hopes for the future. We have dealt to-day entirely with the great undertaking which you,

Sir Samuel Baker, have brought to so successful an issue; but we cannot divest our minds of the fact, that we are at this moment engaged in some serious difficulties somewhat similar to those which you have just described. We know what one Englishman has done under those circumstances. I think we may have confidence that not only one, but many Englishmen, will endeavour as far as possible to emulate the doings of our distinguished traveller. This gives me confidence that we shall not have to deplore anything in the shape of failure. On the contrary, I look hopefully to the future; and although no doubt the difficulties we have to contend with are great, I am satisfied that we have had in our day and in our history many such difficulties that Englishmen have overcome, and I believe the Staff, the individual English Officer and the English soldier are quite as equal to the occasion, as they have been before. What we have heard to-day satisfies me that that will be the result. I think we ought to have implicit confidence in those who serve us in various parts of the world. We know what has been done in India, and what an empire we have founded there. Why should we be afraid that we cannot do now what history tells us we have done before? Prompted by that spirit of enterprise, by that spirit of honesty and straightforwardness which has characterised your proceedings, I am sure that the Government of this country will be able to bring to a satisfactory issue those difficulties in which at this moment we happen to be engaged; I therefore feel most grateful to you for having brought this subject so specially to our notice. I only regret that many of the valuable hints which you have been able to instil into the minds of those who are sitting round you, cannot be at once carried to a distant land, there to be made use of, no doubt with great advantage, where now they are so much required. When I say this, it must be clearly understood that I give the fullest credit to those who are on the spot, and whilst I see what can and has been done by so distinguished an individual as the one who is now amongst us, I feel confident that there are others who are willing, ready, and quite equal to follow in his footsteps.

LECTURE.

Monday, December 22nd, 1873.

GENERAL SIR WILLIAM J. CODRINGTON, G.C.B., Vice-President of the Institution, in the Chair.

BRITISH TROOPS AND SAVAGE WARFARE, WITH SPECIAL REFERENCE TO THE KAFIR WARS.

By Colonel GAWLER, late 73rd Regiment, formerly Military Magistrate with the Kafir Tribes.

A GREAT many lectures have been delivered here and elsewhere on strategy and tactics in regular warfare, but, so far as I know, until Sir Samuel Baker delivered his admirable lectures, nothing of the kind had been attempted on irregular warfare, although, owing to our wide and scattered empire, and our constant contact with uncivilised races, there is no nation more constantly involved in little wars than ourselves.

No one who heard Sir Samuel Baker's lectures could fail to have been struck with the great difficulties he had to contend against, and how much more serious was his work, in having (beyond a dozen or so Europeans) only native troops to depend upon. I know well the loneliness of the feeling of being in command of people not of one's own blood, when they compose the bulk of one's force instead of supplementing it, and when in addition to other anxieties one knows that the courage, sympathy, and loyalty of the force is very evanescent and ready to take wing at very little provocation.

These I say were among Sir Samuel Baker's difficulties, and he proved himself equal to the occasion; he also illustrates the truth of an observation (at any rate in savage warfare) that the best sportsman makes the best soldier.

The task before me, however, besides endeavouring to show the principles of savage warfare, is to point out how far the British soldier is capable of competing in that line, from experiences drawn principally from the last Kafir War.

Before engaging the enemy, however, I will glance over a few preliminaries. In modern regular warfare, I need scarcely remind anyone, an immensity of science is brought to bear, and the army that is best equipped and provided, ought to win; but on the other hand, its requirements are enormously increased—communications must be

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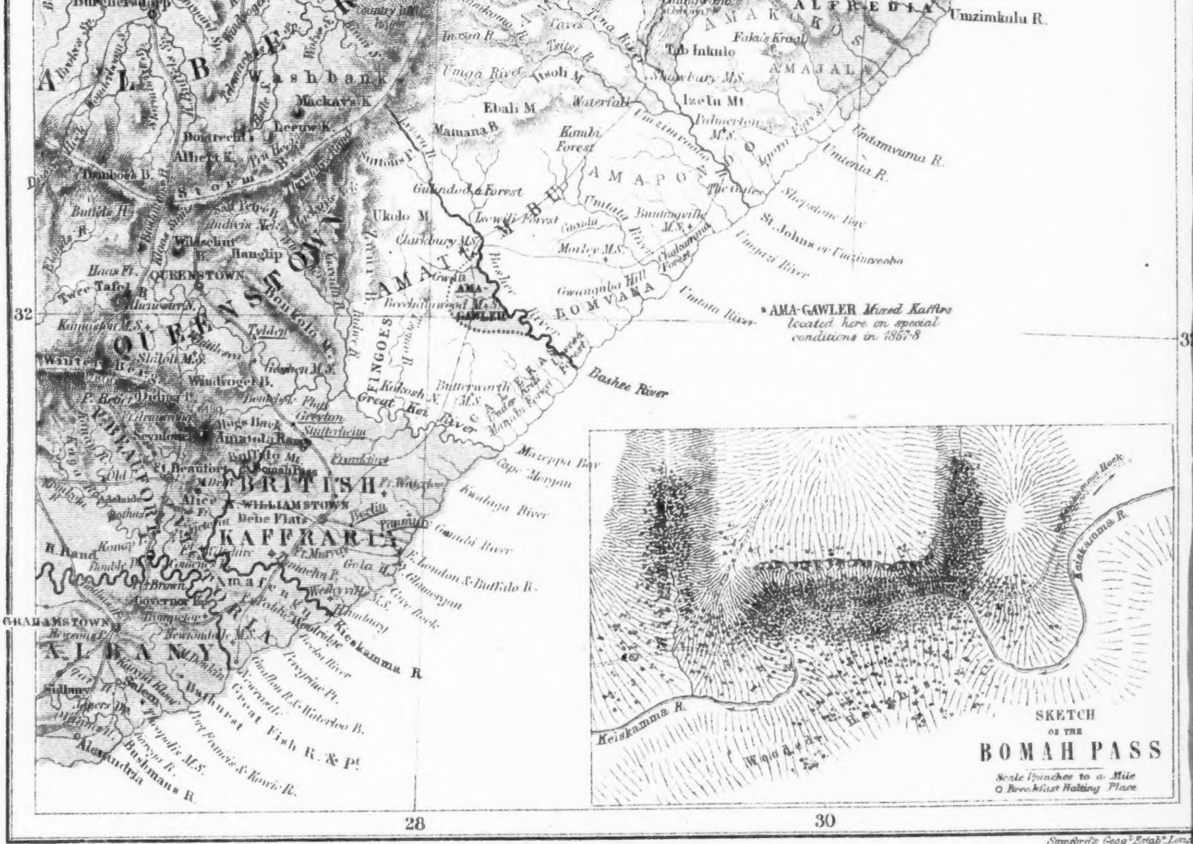
MAP TO ILLUSTRATE COL. GAWLER'S PAPER ON SAVAGE WARFARE.

Journal of the R. U. S. Institution Vol. 17.

Plate LIII



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good and supplies handy to give that expensive and elaborate machine, a modern army, rapid development of its powers and full weight.

Herein often lies the difficulty of dealing with an uncivilised enemy. He generally occupies a poor or difficult country where your scientific appliances are an encumbrance, and even parts of your system unsuitable, and he thus considerably reduces the odds against himself, and the war, for the first part at any rate, is a mere trial of the animal instincts and physical abilities of one race against another; your time and labour are consumed in surmounting the difficulties of the country, in proportion to the impedimenta and novelties that you choose to carry with you.

On the other hand, an enormous amount of time and money is saved in proportion as an army in such a country is able to divest itself of all impedimenta, except what are absolutely required to keep up supplies of food and ammunition and to maintain its health. An uncivilised country cannot be made to receive all at once the appliances that could be made use of in a civilised country; and to crowd an endless variety of stores into a country where the landing and storeage room, means of transport, roads or footpaths are too limited to receive them, tends either to a waste of money and much destruction of stores which are in everybody's way, or to the prolongation of the operations until the country is made fit for their utilisation.*

For the ordinary operations of savage warfare, artillery is not required. It is useful for the defence of camps.

In New Zealand, guns were valuable in attacking some of the formidable pahs.

In the Himalayas I took two howitzers with me, but only because the mortars which I had sent for had not arrived. I wanted these for the attack of the very formidable positions which frequently occurred.

In the Kafir War, guns were of little use, except in attacking certain strongholds, and in Basuto land.

Savage warfare consists for the most part of skirmishing over difficult country, bush or rocks; and guns are only of use, when the enemy crowd together in a position, which is not often the case. Guns, moreover, confine your movements to the good ground and main roads, which the savage as a rule avoids; and in a dense country there really is not scope for a gun, and rockets do all the frightening that is necessary, and are more portable.†

On the subject of tents, I think, if the season be not rainy, and if the country afford the means, it is better to let the men bush it. Sir Samuel Baker's suggestion quite coincides with Cape experience; each man should have a hatchet, and two or three can knock themselves up shelter against all but very heavy rains. Indeed we were out for six weeks at the Bashee in the Kafir war. It rained the whole time heavily, and the men had no shelter but what they knocked up for themselves, or a patrol tent improvised out of one man's two blankets, which two others shared with him. Officers had patrol tents.

* This was a note made during my expedition in the Himalayas in 1861.

† Hale's rockets can be fitted with bursting shells, and the 24-pounders attain a range of 7,000 yards.

When I assumed command of a field force in the Himalayas, one of the first things I sent for on arrival at Darjeeling was hatchets, and they did not arrive a bit too soon. The 6th Royals arrived at the barracks at Sinchal at nearly 8,000 feet elevation—dreadfully cold, and snow was on the ground. The wood contractor failed to fulfil his contract, and the men, though surrounded by a magnificent forest, were perishing in the midst of plenty for want of axes to cut it with.

On the subject of arms:—

In a country of dense jungle, or where the enemy only fights in the bush, I concur with Sir Samuel Baker that the breech-loading smooth bore, which will carry the old musket ball and six to eight slugs, is the best weapon, and a proportion only of rifles; but I do not attach sufficient importance to it, to advocate a change of armament for regular troops sent on such service. Local corps do well to consider such matters. The Cape mounted Police were armed with a double barrel, one smooth and one rifled. In open countries, as Basuto land, the long range rifle is indispensable.

On patrol during the Kafir War, the men, besides their blankets, repeatedly carried three days' biscuit and groceries, so that the slaughter-cattle and Officers' pack and riding horses formed the sole impedimenta. The men also carried groceries for ten days and biscuit for three, and the balance of the biscuit was carried on pack mules —one mule carrying the biscuit for about 30 men for the remaining seven days.

This leads me to the subject of horses and mules; and in this also I concur with Sir Samuel Baker on the desirability of having at least a few mounted men even in a dense jungly country. Apart from any fear which some savages have for horses, it is most important to have a small body of men that can move rapidly; and I have seen very few jungle paths in the Himalayas or the Cape, where horses could not be ridden. It is also most desirable that Staff and Regimental Officers should be mounted; the former certainly, and as for the latter, their work often only begins when they reach camp. In the early days of Natal, before the tribes had settled down, the 45th Regiment which was stationed there, had one company mounted. I don't know why horses are not supposed to live on the Gold Coast, but, if it be that the rank grass is unsuitable, it might be got over. In parts of the Himalayas where there is no grass, horses, cattle, and goats live luxuriously on bamboo leaves, and bamboo seems to abound on the Gold Coast.

I was glad to hear that a portion of the European force in the Ashantee expedition would start from Accra, which is a route well suited to a European force. It is five days longer, but horses live there, and they might therefore have mule transport. Moreover, it starts at once with an elevation of 1,600 feet, the climate is healthy, and European vegetables are procurable.

This properly is a branch of strategy on which I will say a word or two, for in savage warfare, strategy is just as important as in regular warfare. The first point in strategy is to discover wherein, like Sampson's secret, lies the strength of the enemy, and his power to maintain the war.

Savages have so few impedimenta that they are as slippery as eels, and their system consists chiefly in evading your blows, and in administering what may be described as mere stings. The real gravity of the war, is the expense attendant on its long duration, and the great labour and hardship for the troops.

In Sir Charles Napier's campaigns against the hill tribes in Scinde, certain wells of water, a stronghold named Trukkee, and their cattle and camels, were the enemy's tender points. The enemy were gradually forced into Trukkee, and surrendered when they found it turned.

It is more difficult, however, in a country like Kafirland or Ashantee, to ascertain their tender point.

In the former country, the enemy's cattle is *one* object; but the climate is good, and he can live without shelter. There are plenty of streams, and *numerous* difficult localities where he can hide; and this, when the enemy's country is backed by tribes with whom we have no quarrel, but who, ignoring the duty of neutrals, allow our enemy and his cattle to take refuge with them, is embarrassing.

The best system under such circumstances is rapidly to seize by forced or secret marches, if practicable, any passes or lines of retreat, and to sweep the country, in columns of from 300 to 500 men, operating in connection with each other on parallel or convergent *main* lines, upon some obstacle, as the sea, a deep river, or towards more favourable ground, as open country; for concealment is really the mainstay of the savage.

In the Kafir War of 1850—3, we commenced with an inadequate force to patrol the country in a desultory sort of way, and we had also to keep numerous posts provisioned. The Kafirs would amuse themselves by attacking the troops whenever they saw that they were encumbered with anything that they could not well leave. On other occasions they would yield as the troops advanced, but follow up with vigour on flanks and rear, as soon as want of provisions made it necessary for the troops to return.

As our force was increased, patrolling thus from towns and posts, forced the enemy into strongholds, as the Amatola Mountains, the Waterkloof, and Fish River bush; and when large numbers were congregated in such places, battues were organised, or camps established in them, and waylaying resorted to; we also prevented their cultivating anywhere. But although battues, patrolling and waylaying were generally well managed, it was desultory, and I did not see a good combination of them all by the whole force acting in concert on some definite plan.

In Ashantee, I am inclined to think that, though their dwellings are temporary and their baggage light (though not so light as that of Kafirs), the enemy will hold more together, and will give better opportunities for inflicting *blows;* and I think we may reasonably hope that the war will not degenerate into that most difficult and unsatisfactory sort of guerilla warfare, *i.e.*, the action of small parties of the enemy independent of each other, living anywhere, and fighting or annoying us when they like and where they like.

From this we see that anything which will draw a savage enemy

together, is in our favour, whether it be a stronghold, as in parts of Kafir land (so long as it is not of too great an extent), whether it be a New Zealand pah, or whether it be an attempt at organisation on the part of the enemy; for their being drawn together furnishes us with the opportunity of delivering *a blow*.

Savages by attempts at organisation, generally render their movements comparatively heavy.

I now come to the main point of the present lecture, viz., to show how far the British soldier is able to compete with the savage in bush-warfare.

A Kafir war, like most other wars with savages, in its tactics or details, may be described as a war of stratagem. From inferiority in weapons and organisation, the Kafirs, like other uncivilised races, are unable to meet a civilised force face to face. The introduction of breechloaders has made this still more apparent; and, whatever difficulty there may be in catching the enemy to administer a blow, a party of 100 Europeans with breechloaders should now be perfectly safe against enormously superior numbers of savages, unless, of course, the latter possess themselves of similar weapons.

Kafirs are individually brave, and devoted to their chiefs, but like most wild animals, a few will often make a much better fight in proportion than larger numbers. You may chase a herd of buffalo with impunity, as long as your horse will last, but put up two or three old bulls, and they will provide you with occupation.

I may mention as an instance of courage and devotion, that a small party of my Kafir police, under Colonel Colley, had attacked a notorious old warrior and bandit, named Tola, who, with his three sons, and some dozen others, returned the charge, and followed them up fiercely. The police having sent for a reinforcement, taunted the old fellow whenever his party showed signs of giving up the pursuit, and thus drew him on. The re-inforcement arrived, Tola and his three sons were killed, and his men fled, except one old counsellor, who stood alone. He received a call to surrender by wounding with an assegai, the policeman who made it, saying, "I left my kraal with my Chief this morning, and will not return without him." He fought desperately until he was killed.

As a rule, however, selfishness and want of discipline, make the individual savage generally feel that he bears the whole brunt of the battle. His comrades are of little account; he does not rely on them. Hence each man looks out for himself, and decamps when he is so minded.

In the war of 1850—3, the Kafirs were well supplied with arms, of which a great many were percussion, and they were tolerably supplied with ammunition.

To induce a savage to fight, it is a *sine quâ non* that he should have large odds on his side, and that he should be free to withdraw when he pleases. The odds are of course in his favour if he can carry on the fight from under cover, while his foe is in the open. His fondest wishes

are therefore thoroughly gratified by any Officer who, when attacked, keeps his men outside the bush, as on the path, or in the open.

The only effectual plan is to dash at him and unearth him at once; 1st, because, like many better troops, he does not desire close quarters; 2nd, because his party do not actually count on more than their first volley. If that fails to confuse his enemy, or make him pause, his scheme is frustrated, and he has no discipline to enable him to arrange another in time.

His volleys are generally delivered at 80 yards and under, and for troops to pause at one of them, or anything but a forward movement, is to prolong the fight and multiply the risks. Kafirs and Hottentots were often cool enough, after delivering their shots from the edge of the bush upon the troops approaching it, to lie still to observe the effect. If the troops halted and took cover, the Kafirs were quite equal to keeping up the engagement, and took their shots deliberately as any man showed. But if the soldiers dashed straight at them, they disappeared at once, often with loss; for the soldier's eye soon becomes accustomed to the moving branches and twigs indicative of a retreating nigger, who gets more bullets after him than he likes, and becomes very shy of ever waiting again to observe the movements of a foe, who he knows, will come straight at him.

British soldiers can go through anything through which a Kafir can go. They may have to leave bits of their clothes behind on the thorns, but if so, the Kafir leaves bits of his skin. Soldiers soon leave off the regulation attitude, and learn to duck and twist and tear through the more yielding portions. There is no occasion to dash through the middle of a thorn bush; although on one occasion, on the coast near the Bashee, where the bush is stunted and thorny, with strong boughs only about 18 inches from the ground, a sergeant of my company ran a Kafir into it, crawled after him and pulled him out by the leg.

As to the advisability of a line of skirmishers, who are coming across the open towards the edge of a jungle, firing into it whether they see an enemy or no, I have a word to say. In the Kafir war a very excellent and brave Officer adopted such a system in his regiment, but in what I may call slow time and in close order, which was fatal. He formed line in the open within 80 yards or so of the bush and fired volleys into it. The Kafirs and Hottentots lay close, and after each volley rose and took their shots with sad effect. The commanding Officer and several men were killed.

I see no objection to a *few* men, of a line of skirmishers who are running towards the bush, discharging their rifles into it, as if they saw the enemy, who, if he be there, will think that he is discovered and will run, but the forward movement must be unchecked and as rapid as possible. My experience, however, is that the men will do it in spite of orders, and will always declare that they saw an enemy. To sanction the practice would render it intolerable, and the men would hang back. To discountenance it strongly, just reduces it to reasonable limits. Musketry instructors, however, must not lament over bad shooting and numbers of rounds expended when there has been no enemy to hit.

Of stratagem, waylaying and surprises are the commonest forms.

The Kafirs were two or three times very successful in waylaying large bodies of troops. I will mention one instance,—the Bomah Pass,—not as a specimen of waylaying, for there was a mixture of treachery, but to show how we might have acted.

Although a sergeant's party on escort had been waylaid and murdered, Sir Harry Smith had not yet proclaimed war, and Sandilli was the only Chief who did not obey Sir Harry's summons to appear, and he only pretended to be afraid.

Sandilli was in the Amatola Mountains, and a large camp was posted to cut off his retreat to the Kei, and a patrol was ordered by Sir Harry Smith to move from the other end through the Amatolas, not to fight, but as a military promenade, to intimidate him. So much was this the case, that the men were not allowed to loosen a single packet of ammunition. The whole of the country was difficult, and there were only footpaths. The force consisted of a large number of Cape Corps, Kafir police, and I think six companies of European Infantry, including one company of the 73rd. There were the Officers' packhorses and two packhorses with spare ammunition. The troops breakfasted about half a mile from the entrance of the Bomah Pass, and several Kafirs and their women came in selling milk in a most friendly way. After breakfast, the force moved into the Pass. The footpath, which was only wide enough for single file, was through very dense bush,—trees and underwood,—with large rocks here and there by the edge of the path. There was a precipice to the left, and the Keiskamma river flowed about 60 yards down on the right. The river was unfordable just there, or at any rate fording was very difficult. The length of the Pass properly so called (*i.e.*, the densest part, having the precipice on the left and the river on the right) was a little over a mile. The company of the 73rd was in rear, and when the Cape Corps had just got out at the other end, the rear guard was entering. So far all went well, and there was a momentary pause. Presently a shot was heard, then two or three. Then word was passed down to loosen one packet of ammunition but not to load, and afterwards to load but not to fire. At the first shots, the men came down on one knee and remained perfectly steady, and anything might have been done with them; but those were the days when company Officers dared not act without orders, and the Officer commanding the infantry was a mile off, and could not possibly estimate where the tail of his column was. Firing continued and was returned, and presently a bugle sounded from the head of the column "the advance" and "the double." If the bugle meant that the men were to face their foes and advance, all the Kafirs would have been swept into the river if it had been acted on, and there would have been no Kafir war; but it was understood as an order to proceed, and the tail of the column had the whole Pass through which to run the gauntlet. All the packhorses that had not already emerged from the Pass, including the two with ammunition, were lost; but only ten soldiers were killed, so busy were the Kafirs in looting the packhorses.

This is not a fair specimen of waylaying, as it was mixed up with

treachery, and the force was unconsciously led into a trap; but I mention it to show what might have been done. Some months later the 73rd marched through the Pass, and my company moved without any difficulty from one end to the other in skirmishing order through the bush, with one flank on the river and the other under the precipice. (Since then a good waggon-road has been driven right through the Pass, and the Amatolas are no longer a stronghold.)

Should an Officer by accident or neglect ever find himself in such a position, the only safe plan is to dash straight at the enemy. Keeping on the footpath, and firing as you moved along, might clear long grass or mere underwood of men *standing* in it; but if those were your tactics, Kafirs are quite cool enough to lie down within two or three yards of the road behind logs or stones, quite concealed, and the force would run the gauntlet past them, and its fire would go harmlessly over the enemy's heads. Moreover, your own men going along in single file would not know when the danger was passed, and the firing, which had been provoked by perhaps a dozen of the enemy, would be kept up for a mile or two.

Supposing, moreover, that you got through the Pass without loss, what effect would such proceedings have on settling the campaign?

The object of a campaign must consist of something more than seeing how often you can run the gauntlet past an enemy.

In my humble experience, the dash of those nearest to it, straight at the ambuscade not only scares the enemy at the moment, but gives him a lasting respect for you.

But (excluding an affair like the Bomah Pass, which was partly treachery) I will lay it down as a rule that a British force should never be surprised either in camp or on the march.

In the Himalayas, I always reconnoitred in small parties in all directions to long distances, and frequently by night. On such expeditions the parties should notice all sounds and footmarks, *and should be on the look out* for anything that could indicate whether anyone had been in the neighbourhood recently.

There is nothing so foolish as to go to sleep without knowing whether the enemy may not be within half a mile of your sentries.

On the march by footpaths through a dense country, half-a-dozen men at from 50 to 100 yards in front and the same in rear, will serve the purpose of advance and rear guard; flank patroles should move if possible within the bush, but sometimes this, owing to the underwood, would be too much of an undertaking. In this case the leading file must turn to the right, get as far as he can into the bush, kneel and look well under the bushes; the next file in about five paces turn to his left, the next to his right, &c. Thus the whole force is inverted, and extended on both flanks at ten paces; as the rear guard approaches, the files rise in succession and close by sections, moving along between halted sentries. I am told that something similar is recommended in a work by Marshal Bugeaud, and I think Sir Samuel Baker practised it; but I first saw it done in 1851 by Colonel Eyre, in going through a ravine in the Fish River bush, where a large number of another regiment had been killed two or three days previously.

In going through nasty places, it is quite possible that you may be followed up, and seriously annoyed, and it is surprising what a tendency there is under such circumstances *to hurry*. Discipline, however, is something to fall back upon. A little ready action should be taken to meet immediate necessities, and to gain time to make more suitable arrangements.

On one occasion we were leaving the Amatola basin by a footpath through an intricate bit of country, commanded more or less on all sides from slopes covered with dense forest and underwood, from which flank patrols could do little to protect us. The Kafirs were following us up on flanks and rear, and there seemed a disposition on our part to move more quickly than Colonel Eyre thought dignified. He, moreover, was evidently anxious. To recover himself and restore coolness, he gave the order, "halt, lie down and smoke your pipes." The men lay here and there by bushes and rocks facing in all directions. The exultation of the Kafirs vanished, and in a few moments of comparative quiet, Colonel Eyre devised an offensive movement upon them.

Against an uncivilised enemy, surprises ought to be more practicable than against the civilised. The savage has not the system, sense of duty, or persistent energy, that British troops should have, nor is their work supervised. And it may be laid down as a rule that, if the surprise is complete, their rout should also be complete, because they have no discipline to fall back upon, *i.e.*, when their first arrangements are broken through, they have not the power to rally; but this supposes that a surprise means something more than a momentary fright. It is the difference between winning a victory, and making use of it. It is not sufficient to creep stealthily up to an enemy who is sleeping or feeding, and merely startle him. Don't then imagine that you have won a victory! To advance with a British cheer is a grand mistake. I once fell into it myself when, with a party of Umhala's Fingoes (a race inferior to, and in subjection to the Kafirs), I went to surprise a kraal. We had done our night work beautifully, and in the glimmer of the morning could just distinguish the doomed kraal 150 yards off. The rush commenced, and, as the Fingoes went skimming swiftly over the dewy grass, I gave a shout of exultation when within a few yards of the huts. The enemy bolted out of their huts into the opposite bush, and then turned round and shouted the war cry in return, and to some purpose, for I was not prepared to follow them up, and in a quarter of an hour we had to make our way back again with the whole country side after us.

I made two deductions after this mishap, upon which I acted ever after.

1st. When you intend to surprise an enemy, do not *reveal yourself*, but go on quietly and coolly completing your plans until the *enemy* finds *you* out. More correctly, the object should never be to *surprise*, but to *entrap*. In the case I have quoted of myself, the party was rushing forward silently to place themselves some over the doors of the huts, while others would have occupied the bush beyond. My shout *startled* the enemy certainly, but he got away, and, as I was not prepared to follow him, he rallied.

In an ordinary attempt of the kind, on a place surrounded by bush, as soon as it is observed, parties should creep silently round to the right and left, keeping just within the edge of the bush, and they may sub-divide themselves again, to waylay any paths or occupy any favourable points on the opposite side by which the enemy is likely to run. When a few minutes have been allowed for them to get into position, if the enemy be still undisturbed, a strong party may run silently up to the huts; three or four men with bayonets fixed to every door.

If he should still remain unconscious, the form of introduction might be an embarrassing point, but I confess I think I should gently explain the situation to him, and ask him to surrender.

2nd. The second deduction is, never to undertake a morning's job without being prepared (with provisions, &c.) to spend the night from home. It is just *after* the surprise that the real work is likely to begin, if you have failed to entrap him, and you should be prepared to follow him up, or at any rate to assume the offensive if he should presume to follow and harass you on your return home.

This was the most annoying part of three-fourths of the patrols during the early part of the Kafir war. The troops were tied in their movements, and were bound to certain directions and to reach certain points. The Kafirs quite appreciated this, and harassed the flanks and rear.

We now come to waylaying and reconnoitring, and a few of their details.

This, in bushy country especially, is best done by small parties of from a dozen to thirty men; sixty men would be very large, and in a dense country, unwieldy and unnecessary.

British troops are very apt scholars at any exciting work. There may be some obtuse, clumsy fellows, who can never learn to speak in a whisper, or to tread lightly, and who, over rough ground, or among tangled creepers, are always tumbling about, and making a row, but, as a rule, nine-tenths of the men are the very best material you could desire. They must learn to move along silently, all eyes and ears; a sort of stealthy stroll is the best pace for the purpose. Eyes should be on the bush, to mark if any branches, twigs, or creepers have been disturbed by anything going in or out; on the ground, to detect any footmark; and experience will soon teach men to decide whether marks are old or recent. As a rule, in bush you obtain a better sight, and can see further by stooping and looking among the stems and trunks. At a noise, or rustling, or any marks, the party should pause and consider, not in a clump in the middle of the path, but edging sideways, quickly and softly, within the bush. They must consider whether the enemy is coming, or going, or halted, whether he has seen them, and, above all, whether from the marks, it is likely that one or more of the enemy have been already passed, lurking in the bush.

It is impossible to enter into all details. To be all eyes and ears, perfect silence, and concealment, *whether resting or on the move*, form

the pith of it all, and experience finishes the education. Ready wit in hitting off good plans, so as to make the most of the situation, is a gift.

One or two general rules on waylaying may be given.

Never waylay very near to the point at which you leave the road or path. If you have reason to think that an enemy is following you, quit the path at some favourable point when he is not in sight, and return within the bush, parallel with the path for several yards, to some point where there is good concealment, for of course if he were to come upon your footmarks, leaving the path, your scheme would be spoiled. This is a common trick of the buffalo. He will run straight away, and on turning a corner so that you lose sight of him, he runs rapidly back for 200 or 300 yards within the bush, and charges you in flank as you pass.

For similar reasons, when advancing to waylay, always leave the path and move within the bush parallel to it, before selecting your position.

If the path be along the side of a hill, choose the lower side for your party; 1st, because an *up*-shot is best, particularly at night; 2nd, because if you were on the upper side, the enemy would have such an easy retreat by dashing down through the bush on the lower side.

No smoking should be allowed, but the men should have cold tea, or spirits and water, and some biscuit in their havresacks, and a bit of cooked meat or cheese.

It is a good precaution, particularly for small parties moving in the neighbourhood of the enemy, or when returning from waylaying or reconnoitring, never to return to camp by the same route by which they went out. Besides enabling you to see more of the country, it upsets any plan the enemy may perchance have laid for you. When I was a magistrate with the Kafirs, when riding alone I was three times waylaid, but my sticking to this rule saved me.

As to what may reasonably be endured: in the expedition across the Kei, in 1851, the troops for a couple of weeks had, besides their coffee and sugar, only their meat ration and *Indian corn*. The biscuit had run out.

In my expedition to the Bashee with Kafirs, Colonel Colley and I lived for some days on beef and nettles, and I have been out for 48 hours with only biscuit, and I dare say there are many besides myself who could relate greater privations endured for the mere love of sport and adventure.

From a military point of view, these things read like bad commissariat arrangements; but no; on special enterprises you carry supplies with you, and abandon your communications, and, if you meet with more than you expected, it is better to use a little ingenuity and self-denial, and make a good job while you are about it, than to return leaving it half finished, because your supplies are short.

I cannot dwell too strongly upon the importance of Officers and men rapidly acquiring a knowledge of the country and all its roads, footpaths, villages, streams, &c., and, for this purpose, an efficient staff of field sketchers should be employed in a country not already known. At the Cape we had an admirable map by Colonel Jervois, of a portion of the seat of war; and at a later period, my friend Colonel Colley made

a beautiful and minutely accurate survey of the country between the Kei and Bashee, but I fear that it is at present decaying in the Survey Office at King William's Town.

I will now give a few specimens of the work of small parties.

During the Kafir war, when the power of the Kafirs was a good deal broken, and the Chiefs were lurking with comparatively small numbers in the densest parts of the Amatolas, Fish River, Waterkloof, and Kei, Colonel Eyre, with the 73rd and 43rd, had a standing camp in the Keiskamma Hoek, in the middle of the Amatolas.

The Kafirs could not live altogether on nothing, so they always had parties out thieving, or bringing supplies of corn, &c., purchased among friendly tribes (although I was told by a Kafir after the war, that when acting as spy he lived for three days on his sjambok). Sandilli himself was believed to be in the Amatola basin, and small parties in the Wolf Valley. Colonel Eyre detached my company, about 60 strong, to live in the bush on the Wolf ridge, and to draw supplies every three or four days from the main camp, and I had permission to do as I liked. If I had done nothing, I have no doubt that in two or three nights I should have been attacked. But I thought that if any fun was to be had, it would be while the ground was fresh. On the first evening I took a sub-division, and went along the ridge, about a mile, to above the Bomah Pass, and took 12 men down and posted them, to waylay it. As it was a nasty place, I promised to come to them at night, when my other work was done. I then went back with the remainder of the men to camp, and took out the other sub-division in the opposite direction, and posted three parties, two of 10 men, and one of 6, waylaying three different paths. It was quite dark, and I returned to camp with a few men. After dining there, I went alone and joined the Bomah Pass party, as I had promised, but we passed a quiet night. In the morning I found that two of the other parties had made their bags of several Kafirs, and had captured two horses laden with corn. The corporal in charge of the smaller party had managed rather cleverly. The path was along the side of a hill, and his party was lying on the lower side. Several Kafirs came past, and he fired and then charged. Three or four Kafirs were killed, and the others dispersed. The corporal and his men kept together, got on the path again, and ran quietly down it for some distance, and waylaid again. The Kafirs in their turn began to feel for the path again, to continue their journey, and presently a single Kafir, acting as an advanced guard, passed the corporal's party. They let him go by, and the others came along and got another volley and charge, by which two more were killed. A prisoner, taken by one of the larger parties, told us of Sandilli's whereabouts, and Colonel Eyre drew out his whole force at once, and enclosed a vast extent of country, but the news had also reached Sandilli, and he got clear out of the district.

In 1852 the Kafirs had congregated in considerable numbers in three or four places in the Fish River Bush. This is a tract of low, intricate country, from three to ten miles wide and fifty miles long, through the middle of which the Great Fish River winds. It is covered with dense bush, and from the margins of the high ground come long and tortuous

ridges, forming necessarily numerous intricate ravines and valleys, affording excellent concealment for large bodies of Kafirs; plenty of wood and water, and a few small, open, grassy patches where they could graze a few cattle. This place was their base, and from these various camps they used to send forth marauding parties upon Lower Albany and the neighbourhood of Graham's Town. Colonel Eyre was sent with four companies of the 73rd and some Cape Corps to protect those districts. He formed five camps, from two to three miles apart, in select corners on the high ground above the bush. The Officers commanding these posts made themselves acquainted with every road and footpath entering the bush between them and the neighbouring camps, and for long distances into the bush. Daily patrols detected if anyone had been in or out, and parties moving off at dark spent the night in waylaying. At first the excitement was great and the bags large, but the Kafirs soon thought it too hot, and made their depredations in other directions. Then, without abandoning his line of camps, Colonel Eyre used to send parties of 30 or 40 men off to long distances with three days' provisions. These used to remain during the day at a little distance from the path to be watched, under rocks or cliffs, leaving one or two men on the look out at the edge of the path. Near high, blueish rocks, or among very tall trees, fires might be lit, as the smoke loses itself, but among low trees or bushes the men were not allowed to light any fires by day or night. These parties had several successes, and the Kafirs abandoned the whole of the Fish River Bush that was within our reach.

But it is not by single efforts that great results are to be obtained. I have often thought that if two other regiments had been spared for a time on the same job, posted in similar fashion to ourselves on the opposite side of the Fish River Valley, and above and below the principal Kafir laagers or camps, and if all had worked on the same plan in connection with each other concentrically upon the Kafirs, moving forward the camps and narrowing the circle gradually, waylaying, watching, and patrolling, we might have settled more effectually in ten days, what took us three months, and the Kafirs, instead of abandoning the place to maraud elsewhere, would have been *caught*.

In my own district in Kafir land, after the Chiefs had compelled their people to kill all their cattle and destroy their corn, those who did not die of starvation or go into the colony, broke up into knots of banditti under favourite Chiefs; and the people who had opposed their Chiefs and had refused to kill their cattle, placed themselves under me, and with them I set to work to break up or capture these knots of banditti, and I found that by watchfulness, patience, secrecy, and some hardship, the concentric action of small parties from a wide front (the extent of my district gave me a front of 30 miles towards the disturbed parts), was most effective, and we captured or broke up the whole of them.

In the *United Service Gazette* I read a journal of an Officer in the New Zealand War. He describes some excellent practice in waylaying and ambuscades, but these appear to have been from stationary posts, and their influence could only extend to a certain radius, beyond which

the troops must either be encumbered with supplies, or run the risk of being compelled to fall back, with the enemy harassing them.

Such warfare in fact, to be successful, must be like driving game with a long line of beaters; but in their advance these beaters must be fed, relieved, supported, &c., and no gap left for the game to break through.

Night marches are most useful and effective, though somewhat difficult to conduct when the route is by footpaths through bushy or intricate country. The men in rear stumble if the head of the column moves at an ordinary pace, and the march is often broken. A man falls, jumps up, and having lost sight of the man in front of him, runs ahead, misses a turn in the footpath, and those in rear follow him, and presently two-thirds of the force find that they are following Private Thomas Atkins, who has not a notion where he has got to.

I did a great deal of night work in the Himalayas, and the marches were generally very successful; but on one occasion I found I had lost my tail, and went back. Presently I heard the voices of the lost ones, and waited a little for them, but they came no nearer. I went on to them, and found about twenty walking round and round a clump of bamboos.

However, a slow, sure pace, a sort of sauntering, leisurely pace, frequent halts, say every twenty minutes, and a good Officer in rear, will always succeed, and in a climate where the night air is not likely to injure the health, night marches will be found most valuable.

The principles herein laid down are those practised by Colonel Eyre; and by them the 73rd, though through the whole war and constantly out, suffered very trifling loss, and entirely escaped the disasters which befel many other regiments.

As regards the recent disturbance at Natal, I don't think much about it; but it is just one of those unpleasant occurrences which may arise out of a want of uniformity in our dealings with natives.

There is some discontent among the Natal Kafirs at finding they are kept tighter in hand in Natal than in other places under British rule, and one Chief has resented it by moving off with his tribe into Basuto Land, without, I understand, paying his taxes. But Basuto Land has, I believe, recently come under our control.

The Natal Government tried to stop him, and occupied all the passes with very weak parties, but the Chief forced his way through, and killed two or three Europeans of the Volunteer force.

I think it was a pity that they tried to stop him. I really think it should have been considered a boon to get rid of such a man. His location cut up into farms, was worth more than the amount due. It would have turned the laugh against him, and the other Chiefs would be very cautious about abandoning their locations in a huff. I would even have furnished the retiring Chief with a letter of introduction to the authorities on the other side of the mountains, explaining that he was a very disagreeable fellow, who required looking after, and that they were quite welcome to him.

Natal and Basuto Land are both open countries, very easy to work, and could be thoroughly managed in a short campaign by the mounted

burgher force, supported by a small force of British infantry, but the operations should be conducted by a military Officer acquainted with his profession.

The different Colonies or Governorships in South Africa would do well I think to compare notes on the native question, and as far as possible assimilate their laws and restrictions.

The natives of Natal have hitherto been well conducted; but as a people progress in knowledge and power, we must, I think, give them more freedom, or they certainly will resent the continuance of a tight hand.

The natives could not possibly maintain a war *in* Natal. They must retire on one of the neighbouring tribes and persuade *them* to go to war, but by the extension of the White Settlements, all these tribes,—Zulus, Basutos, or Amapondos, are enclosed,—and a war properly managed on our part would very soon prove fatal to their independence.

The CHAIRMAN: The subject Colonel Gawler has brought to our notice, is one of course of very great interest at present, for the war in Kafraria was very similar in its details to what is now taking place in Ashantee. I dare say there are many Officers or gentlemen here present who know the West Coast of Africa, and we shall be very glad to hear any remarks they may wish to make.

Major-General COLLINSON, R.E.: As no one seems inclined to follow Colonel Gawler into the bush, I will lead the vanguard. I have nothing to say particularly upon the subject of Africa, but I should like to put the subject before the Institution in a more general way. In the first place, I think we must express our great thanks to Colonel Gawler for the trouble he has taken in putting this question before us in so clear and detailed a manner, because I believe it to be one of greater importance than people generally imagine. I suppose we shall all allow that we are not by any means at the end of our native wars, but, on the contrary, we appear to be really only just commencing to conquer Africa; therefore, the probability is that this discussion will be of great value hereafter to the British Army. Colonel Gawler has mentioned a great number of most valuable details upon the subject of "bush-warfare" in different countries, and I think we may gather that upon the whole, there is this one peculiarity which is almost certain to be found in every native warfare, that the country will be probably exceedingly difficult for regular troops; that easy and open country will be the exception; therefore close country is the style of country we must calculate upon and prepare for. This question may be looked upon from two points of view: first, the most effective and, therefore, the most economical way of keeping the peace on the frontier; and, secondly, the effect that bush fighting will have upon regular British troops. With regard to the first point, native wars do not occur in that systematic and public manner that civilized wars do. They almost invariably originate in some trifling manner, and to a very small extent, which could probably be stopped in very many instances by a small body of efficient troops or men expressly suited to the purpose. Such a body, for instance, as has been raised in several of our colonies, like the mounted police and others of that description. I believe if there were a large number of that body located in our colonies, and on the different native frontiers where there is any liability to such an outbreak, it would, in very many instances, stop the larger wars, and keep an effective peace, as far as the settlers were concerned, upon the frontier. Probably the case that has just occurred at Natal is a case in point, where a good effective body of armed police will put an end to the question for the time being, and perhaps for ever. The second point is a more serious one for us, that of the effect of bush fighting upon regular troops; and I think it must be allowed that there is scarcely any native war in the history of the world, whether in America, Russia, the Cape, or New Zealand, that has not been an unsatisfactory war. I do not mean to say that it

has not ended in credit to the troops, or that it has not produced peace, but it has been at a very much greater expense in men and money than the thing was worth. In that point of view it would be desirable always to have the assistance of a special body of men. Now, such a body of men was employed for some time in New Zealand and at the Cape, and if there had been such an effective body of men at the present time on the coast of Africa they would no doubt have been a very great assistance previous to the arrival of the troops there. But the injury that is done by the introduction of regular troops into bush fighting is, in affecting that discipline and steadiness which we consider such an essential point in the British Army. There is no doubt the change of tactics that is going on now in civilized armies, tends in the direction of a looser description of warfare, but it is not likely ever to take such an extremely loose description as is necessary in bush warfare; therefore a warfare in a difficult bush country against natives will always have a serious effect in impairing the steadiness and discipline of regular British troops, and on that account it is, I think, extremely desirable that a very much larger number of special men should be employed, and a greater quantity of money should be expended in securing the native frontiers, wherever we found a British settlement.

Major DUNDAS, late 12th Regiment: Mr. Chairman, the last speaker has said something about bush warfare spoiling the *morale* and discipline of the troops. Now I think that has been very much overstated. At the close of the Kafir War the troops were brought in from the bush, where they had been, some two and some three years, but I do not think that when they were brought into towns like Grahamstown and Fort Beaufort, there was really any want of what may be called discipline. There really was no insubordination: in fact there was but one crime, and that was the crime of the British Army, drunkenness. It so happened that they were often out for six or eight months at a time without receiving a penny of their pay. On their return into the towns, their pay having accumulated during their absence, they found themselves in command of money, and filled the grog shops, where they got a most abominable sort of stuff called brandy, that was sold at about ninepence a bottle. The consequence was scenes of drunkenness, which cannot be conceived except by those who witnessed them. But as for any want of discipline I do not think I can recollect a single case of insubordination. The men had lived so long with us in the bush, and had been so accustomed to look up to us, that we had more control over them than if they had been in barracks. Certainly their appearance was very bad. I recollect on one occasion marching into Grahamstown with my company, where the greater part of their lower garments were made of old sacks sewn up, otherwise they might have been taken for a Highland regiment. There is one thing we must remember, and that is, that soldiers when in the bush require to be fed, and that feeding is one of the most difficult and the most interesting pieces of work that we have to do. I had about six months of it out there with 100 infantry, 25 Cape Corps, and about 150 natives, and we were supplied by waggons once a week. A more insane system could not be invented. There were two men to each waggon for waggon guard. The result was the Kafirs attacked a waggon, and shot the oxen. There was a stop immediately, the waggons could not pass one another. Shouting and firing took place from one end of this long straggling column to the other. The oxen were cut out of the waggons, some of the men were shot, and the Kafirs made away with the oxen through the bush, leaving the waggons there to be plundered at their leisure. I adopted quite a different plan. The evening before we were to line the bush, as it is called, I sent out a body of the Fingoes, my allies, who carefully erased all footsteps on the paths that led on to the main road; and early in the morning I sent out again, and if no footsteps had been seen, I knew the Kafirs were not near the bush. I therefore put men generally in places where it was likely the Kafirs would come up. It was a very difficult country, and on the left hand side of the road there was a deep ravine; it was always regarded as one of the worst places in the colony to look after. In reality, this ravine was a great safeguard, for there were only three places where the Kafirs could climb up out of this ravine and attack the road. I put a corporal and three men in each of these places, and for five months all that I ever lost by the Kafirs was one fat ox; I never lost a waggon and I never lost a man. When we first went up into the mountains, the men, I won't say were afraid, but they did not like to go into the bush. The bush

there is not continuous, but inside the outer fringe there are large open spaces, perfectly clear, where you may manœuvre in any way you like. When you come to the edge of the bush, there is a depth of about twenty yards of very thick dense bush. Once through that, and you find yourself in an open forest. Our men did not know that; they saw the thick bush, and they did not know at the time that when they got inside, they would find themselves on an equality with their adversaries. Once in the bush, and the English soldier is fully a match for the Kafir or any other native; the only thing is, they require practice, and the men know it themselves. I have walked and ridden through the whole of the bush, and to call it impenetrable, is simply nonsense. There are parts that you cannot get through, but I would engage to take 500 men through that bush if they were only taught how to do it. Our men now say that if another Kafir war were to break out, they would make short work of it. The regiments sent out from England had heard terrible stories about the bush and the Kafirs, which the colonists rather magnified than otherwise, and they had a horror of the bush. But I am bound to assert, that any English soldier will by a little practice become perfectly equal to any native I have ever seen in warfare, whether on the open or in the bush.

Captain COLOMB, late R.M.A.: I should be glad if there were any gentlemen here who have a knowledge of the West Coast of Africa, and who can give us information with respect to the possibility of employing horses there. My reason for asking that is, that I have had a very large experience of a climate and locality something similar to that of the coast of Africa—I allude to Central America, Nicaragua and Mosquito territory. I happened to be out there at the time that Walker, the filli-buster, was endeavouring to conquer the country, and I was employed there some short time, and horses were of the greatest possible service. They were fed on bamboo leaves. There is another point connected with British troops in savage warfare, which I think merits some attention, although it has not been touched upon by the Lecturer: it is the danger of using rivers as a means of communication, for many disasters have occurred to British troops and British forces from using rivers for that purpose. With regard to the general question, it is worthy of note that this Institution has supplied a want which must be acknowledged by all who consider the present state of the organization of our forces and the administrative power. England embraces in the folds of her Empire more square miles of bush territory, and more savage people, than any other civilised power. It is reasonable to suppose, and past history shows it to be the case, that for one war we have with a civilised power, we have about ten with savages; yet with all our boasted reorganization, that fact appears to be totally passed over; and I doubt whether, if we had rumours of disturbances within our territory in New Zealand, or in Honduras or at the Cape, when the administrators of our war forces wished for information as regards those countries, they would find the information anywhere else but in the records of this Institution.

Captain OWEN, R.A.: With reference to the employment of horses on the West Coast of Africa, it is stated that horses and cattle can live in the neighbourhood of Accra, but not elsewhere in that country. When they get into the bush, they are attacked by the tzetse fly, and gradually die off.

Captain C. D. MILLER, R.N.: I do not know much about the shore on the West Coast of Africa, but six years ago I was senior Officer on the West Coast, and from what I heard, it appeared that horses, mules, &c., died from loin disease; they would only live a short time; also that the bush in that country will not fire; it is covered with very dense jungle. (The CHAIRMAN: It is disease, not the fly?) I never heard of the tzetse fly being in that district; it may be, but I have never heard it mentioned, only the loin disease. Captain Glover had some thorough bred horses, very small ones, no bigger than ponies, which had been sent down to him from the head Ameer on the River Niger, and they lived because they were born and bred in the country. They were very poor things; but imported horses and mules will not live there.

The CHAIRMAN: I quite agree in some respects with what has been said about the discipline of the English soldier. The discipline of the English soldier, I believe, comes out better when he has difficulties to contend with; and the very fact of his

getting back into his quarters without insubordination, shows that there was that real discipline which we all wish to see, and which is indeed established in the English Army. I think the difficulties rather tend to increase that discipline than to mar it. We must all thank Colonel Gawler for his kindness in giving us this lecture. I only wish we could have had more information with regard to the present seat of war, in order to compare it with the very interesting account that we have had of the Kafir war.

The Journal

OF THE

Royal United Service Institution.

VOL. XVII. 1874. APPENDIX.

PROCEEDINGS OF THE FORTY-THIRD ANNIVERSARY MEETING.

THE FORTY-THIRD ANNIVERSARY MEETING of the Members was held in the Theatre of the Institution, on Saturday, the 7th March, 1874.

Admiral Sir ALEXANDER MILNE, G.C.B., Lord of the Admiralty, in the Chair.

Previous to the commencement of the business of the day, the Chairman read a despatch received the night before, announcing the burning of Coomassie, and the return of the troops towards the coast.

I. The SECRETARY read the notice convening the Meeting.

II. The Secretary read the Minutes of the Forty-second Anniversary Meeting.

III. The Annual Report of the Council was read as follows:—

1. IT is with much pleasure that the Council submit their Forty-third Annual Report.

MEMBERS.

2. Forty-eight Life, and two hundred and forty-seven Annual Subscribers, making a total of two hundred and ninety-five new Members, joined the Institution during the past year. The loss by death amounted to ninety-four, and thirty-four Members withdrew their names, whilst the names of seven have been struck off the list in consequence of the non-payment of their subscriptions, after frequent applications. The net increase therefore is one hundred and sixty.

A detailed statement of the changes in the List of Members, and a tabular analysis of the past and present state of the Institution, will be found on pages vi and vii. By this analysis it will be seen, that the number of Members at the close of 1873, was greater than at any previous period.

FINANCE.

3. The usual Abstract of the Yearly Accounts, as audited on the 12th February, will be found on the following page.

GENERAL ABSTRACT OF THE ACCOUNTS OF THE ROYAL UNITED SERVICE INSTITUTION, FROM 1st JANUARY to 31st DECEMBER, 1873.

EXPENDITURE.

	£ s. d.	£ s. d.
Secretary's Salary	300 – –	
Ditto Lodging Allowance	50 – –	
		350 – –
Librarian's Salary...	...	200 – –
Acting Clerk's Salary	...	79 – –
Fee to Architect	...	26 5 –
Servants' Wages	...	470 1 8
Ditto Clothing...	...	47 11 6
Insurance...	...	11 5 –
Ground Rent	...	202 1 6
Fuel	...	89 6 6
Lighting	...	46 13 4
Annuity to John Pitt	...	20 – –
Assessed and Income Taxes...	...	62 17 3
Parish and Water Rates	...	97 12 –
Artificers	...	163 3 7
Museum	...	99 7 7
Library, Reading, and Topographical Rooms ...	...	221 2 3
Advertisements	...	192 3 11
Printing Circulars and Stationery	...	161 5 7
Lectures	...	38 5 6
Journals, including Annual Report and List of Members ...	...	1,449 10 6
Postage { Letters...	30 3 –	
Postage { Journals	203 12 10	
		233 15 10
House Expenses and Sundries	...	44 7 8
Cash repaid to Agents	...	10 – –
Charges from ditto	...	– 1 11
Balance at Bankers	...	1 – 2
		£4,316 18 3
For £538 10s. 3 per cent. Consols, Life Subscriptions ...	...	500 – –
Balance at Bankers	...	148 10 –
Total Income and Life ...	...	£4,965 8 3

RECEIPTS.

	£ s. d.	£ s. d.
Balance at Bankers, 31st December, 1872		155 8 0
Annual Subscriptions, at 10s.	320 10 –	
,, ,, above 10s.	2,371 15 1	
,, ,, arrears	59 13 –	
,, ,, advance	21 – 6	
Increased Subscriptions, at 10s.	3 10 –	
		2,776 8 7
Entrance Fees		295 3 –
Donation		1 – –
Dividends		291 19 2
Interest on Exchequer Bills		21 10 4
Government Grant		600 – –
Sale of Journals		173 6 2
Miscellaneous Receipts		2 3 –
		£4,316 18 3
Balance of Life Subscriptions at Bankers, 31st December, 1872 ...		113 10 –
Life Subscriptions		535 – –
Total Income and Life		£4,965 8 3

Examined and found correct, 12th February, 1874.

J. E. A. DOLBY
TOB. G. RIDGWAY } Auditors.

T. D. SULLIVAN, Accountant.

Estimate of Receipts and Expenditure for the Year 1874.

Expenditure.	£	s.	d.
Secretary's Salary and Lodging allowance	350	–	–
Librarian and Accountant's do.	200	–	–
Acting Clerk's do. ..	80	–	–
Servants' Wages	500	–	–
Ditto Clothing ..	50	–	–
Insurance	11	5	–
Ground Rent	205	–	–
Fuel	100	–	–
Lighting	50	–	–
Assessed and Income Taxes	100	–	–
Parish and Water Rates	110	–	–
Artificers, Repairs, &c. ..	150	–	–
Museum	150	–	–
Gold Medal (Dies) ..	100	–	–
Library and Topographical Departments	250	–	–
Advertisements	150	–	–
Printing Circulars, & Stationery	180	–	–
Lectures	50	–	–
Journals	1,000	–	–
Postage of Journals ..	250	–	–
Postage	60	–	–
Printing Annual Report and List of Members ..	50	–	–
House Expenses and Sundries	60	–	–
Balance ..	83	15	–
Total.. ..	£4,290	–	–

Receipts.	£	s.	d.
Balance at Bankers, 31st Dec., 1873	150	–	–
Annual Subscriptions:			
£ s. d.			
At 10*s.* .. 320 – –			
Above ..2,500 – –			
	2,820	–	–
Entrance Fees	250	–	–
Dividends	300	–	–
Interest on Exchequer Bills	20	–	–
Government Grant ..	600	–	–
Sale of Journals	150	–	–
Total.. ..	£4,290	–	–

J. F. A. DOLBY
TOS. G. RIDGWAY } Auditors.

Examined and found correct, 12th February, 1874.

Life Subscriptions.

4. Life Subscriptions to the amount of £500, including £113 10*s.* not invested last year, have been invested in Three per Cent. Consols.

Capital Account.

5. The funded property of the Institution on the 1st January, 1874, was £9,465 2*s.* 4*d.*, as compared with £8,926 12*s.* 4*d.* on the 1st January, 1873.

The Future Locality of the Institution.

6. Although the Council have every reason to expect a satisfactory solution of this question, they are unable to make any report with reference to it, whilst the disposition of the Crown lands in, and adjoining Whitehall, is still under consideration.

Lectures and Journal.

7. Thirty-two Lectures were delivered, and sixteen Papers were read in the Theatre, last season. Of these, eight Lectures were delivered to Officers of the Artillery Volunteers, and six to Officers of the Rifle Volunteers. The former series has been published by the National Artillery Association, the latter by this Institution.

Upwards of 21,000 numbers of the Journal, containing more than 130,000 Maps, Diagrams, and Plans, have been distributed to the Members (6,000 by hand, and 15,000 by post), while 833 numbers have been sold. It is gratifying to find that the sale of the Journal has been considerably larger than at any former period.

This large issue has caused a considerable increase of expenditure, hich the Council do not regret, feeling convinced that the diffusion of professional knowledge cannot be better secured, than by the circulation of carefully edited, and liberally illustrated, Papers and Discussions.

In no former year, have subjects more varied in character, or more important in their bearings, been submitted for the consideration of the Members, and the Council tender their thanks to all who have contributed so much valuable information.

Library.

8. Four hundred and sixty-six volumes were added to the Library during the past year; of these, 262 were purchased, and 204 presented. Among the latter, the following are the most noteworthy:—

By the Austrian Government—
Der Krieg in Italien, 1859.
Mittheilungen über Gegenstände des Artillerie- und Genie-Wesens.
Mittheilungen aus dem Gebiete des Seewesens.
Organ des Wiener Militär-wissenschaftlichen Vereines.

By the Danish Government—
Three Sheets of the Topographical Atlas of Denmark.

By the French Government—
Revue Maritime et Coloniale.
„ *Militaire de l'Etranger.*

By the German Government—
Archiv für die Artillerie- und Ingenieur- Offiziere des Deutschen Reichsheeres.
Jahrbücher für die Deutsche Armee und Marine.
Militärische Blätter.
Militair- Literatur- Zeitung.

By the Italian Government—
Rivista Militare.
Rivista Marittima.

By the Russian Government—
Engineering Journal.
Naval Review.

By the Spanish Government—
Memorial de Ingenieros.

By the Swiss Government—
3rd Part of the Topographical Atlas of Switzerland.

By the United States Government—
Eleven Volumes on Military and Naval subjects.

The exchange of Journals with Foreign Governments, and with various Scientific Societies, in this and other Countries, has been continued.

The Library now contains 16,227 volumes.

Topographical Department.

9. The Secretary of State for War has presented Photographs and Lithographs of Guns, Casemates, Shields, Targets, &c.

The Institution has also received from the Lords Commissioners of the Admiralty, Charts, Sailing-Directions, &c.

Museum.

10. Half-block Models of H.M. Ships "Fury," "Superb," and "Temeraire" have been ordered; and a Model of the 9-inch Moncrieff Gun Carriage has been purchased for the Museum.

Various additions (some of much interest), have been made by presentation; these will be found recorded in the Proceedings of the Anniversary Meeting, and in Appendix to Vol. 17 of the Journal. The thanks of the Council have been tendered to the Secretaries of State for War and of India, to the Lords Commissioners of the Admiralty, and to the several donors, for their respective contributions.

Vice-Patron.

11. The Council regret to record the death of one of the Vice-Patrons of the Institution, Admiral the Right Hon. the Earl of Hardwicke, D.C.L., F.R.S. The late Earl became a Member of the Institution in 1835, and was elected a Vice-Patron in 1840.

Vice-President.

12. By the death of General C. R. Fox, late Colonel 57th Regiment, the Institution has been deprived of one of its earliest Members and warmest supporters. General Fox served on the first Council of the Institution in 1831, and was elected a Vice-President in 1840.

The Council have had the pleasure of electing, as a Vice-President, Captain Edmund Packe, late Royal Horse Guards, who had served on the Council many years.

Honorary Members.

13. The Council have elected Lieut.-Col. Roerdansz, of the Prussian Staff, and formerly Military Attaché to the North German Embassy in London, an Honorary Member of the Institution: several other Foreign Officers were also elected Honorary Members during their stay in this country.

Corresponding Members of Council.

14. The number of Corresponding Members of Council on the 1st January, 1874, was 353, as compared with 349 on the 1st January, 1873.

The Council tender their thanks to their Corresponding Members, and especially to those who have been most energetic and successful in inducing their brother Officers to join the Institution.

Gold Medal.

15. The Council have decided that a Gold Medal be granted annually for the best Essay on a Naval or a Military subject, to be determined on, each year, by the Council. The subject for the ensuing year will be of a Military character. The Medal will be presented to the successful competitor at the Anniversary Meeting.

Conclusion.

In concluding this, their Forty-third Annual Report, the Council congratulate the Members on the satisfactory condition of the Institution.

Statement of Changes among the Members since 1st January, 1873.

	Life.	Annual.	Total.
Number of Members, 31st December, 1872 ..	1,009	3,107	4,116
,, ,, joined during 1873 ..	48	247	295
	1,057	3,354	4,411
Changed from Annual to Life	+14	−14	
	1,071	3,340	4,411

Deduct—Deaths during 1873 ..	Life. 20	Annual. 74			
Withdrawals ..	—	34			
Struck off	—	7			
	20	115	20	115	135
Number of Members on 1st January, 1874 ..			1,051	3,225	4,276

Tabular Analysis of the State of the Institution,

To 31st of December, 1873.

Year. 1st Jan. to 31st Dec.	Annual Subs. received.	Entrance Fees.	Income (from all sources).*	Life Subs. received.	Amount of Stock†	Invested in the purchase of Books, &c.	No. of Vols. in Library.	No. of Members on the 31st Dec.	Number of Visitors
	£	£	£	£	£	£			
1831	654	..	654	1,194	..	..	..	1,437	..
1832	1,146	..	1,146	973	..	..	..	2,699	..
1833	1,405	..	1,450	692	..	..	..	3,341	..
1834	1,500	..	1,549	583	1,100	..	..	3,748	13,376
1835	1,480	..	1,574	366	2,430	40	..	4,155	8,537
1836	1,570	..	1,682	330	3,747	45	..	4,069	8,521
1837	1,549	..	1,747	222	4,747	180	..	4,164	10,907
1838	1,462	..	1,634	230	5,500	246	..	4,175	15,788
1839	1,399	..	1,565	168	5,500	292	..	4,186	16,248
1840	1,363	..	1,525	198	5,500	446	5,500	4.257	17,120
1841	1,450	..	1,643	186	6,000	243	5,850	4,243	19,421
1842	1,373	..	1,565	144	6,400	373	6,450	4,127	21,552
1843	1,299	..	1,494	140	6,700	237	7,000	4,078	27,056
1844	1,274	..	1,408	112	3,000	298	7,850	3,968	22,767
1845	1,313	..	1,466	228	1,500	127	8,100	3,988	21,627
1846	1,298	..	1,456	138	1,500	74	8,410	4,031	32,885
1847	1,314	74	1,502	132	1,700	37	..	4,017	38,699
1848	1,175	57	1,375	48	1,700	85	9,641	3,947	37,140
1849	1,176	72	1,375	84	1,150	58	..	3,970	33,333
1850	1,141	106	1,294	198	600	36	..	3,998	33,773
1851	1,136	131	1,292	66	666	34	10,150	3,188	52,173
1852	1,134	133	1,281	114	200	43	10,300	3,078	20,609
1853	1,243	319	1,684	264	528	41	10,420	3,251	25,952
1854	1,200	138	1,368	126	612	95	10,587	3,171	22,661
1855	1,159	107	1,289	120	653	55	10,780	3,131	14,778
1856	1,216	197	1,519	156	761	47	10,832	3,204	16,184
1857	1,258	176	1,937	78	1,038	40	10,960	3,168	12,755
1858	1,318	221	2,102	105	438	31	11,062	3,246	25.747
1859	1,526	195	2,277	512	946	70	11,320	3,344	28,739
1860	1,961	298	3,577	397	2,178	114	11,517	3,518	28,011
1861	2,122	305	2,899	266	2,846	99	11,812	3,689	23,296
1862	2,296	242	3,127	239	3,178	109	12,026	3,797	27,215
1863	2,379	218	3,100	405	3,583	143	12,296	3,847	18,150
1864	2,425	215	3,253	222	4,516	116	12,700	3,902	17,276
1865	2,435	154	3,467	235	4,804	137	13,000	3,895	18,253
1866	2,435	157	3,488	299	5,486	150	13,327	3,891	17,067
1867	2,431	141	3,467	208	5,732	140	13,800	3,823	17,211
1868	2,446	184	3,534	297	6,396	119	14,100	3,812	16,417
1869	2,368	165	3,485	238	6,653	232	14,669	3,792	15,947
1870	2,376	178	3,493	333	7,313	140	15,055	3,831	18,654
1871	2,455	237	3,677	538	7,748	202	15,501	3,922	19,420
1872	2,620	336	4,111	713	8,927	192	15,761	4,116	19,773
1873	2,776	295	4,316	535	9,465	222	16,227	4,276	18,183

* Including Annual Subscriptions, Entrance Fees, Donations, Legacies, and Interest on Funded Property and Grant from Government, commencing in 1857.

IV. Lieutenant-General the Hon. Sir ALEXANDER HAMILTON-GORDON, K.C.B.—

I rise to propose the first Resolution, viz.:—

"That the Report now read be adopted, and printed for circulation among the Members."

We may congratulate ourselves, Gentlemen, on the continued prosperity of the Institution. For upwards of forty years it has gone on increasing in importance, both by the number of the Members joining it, and by the amount of subscriptions received. The statement of accounts, also, is satisfactory, inasmuch as the expenditure is within the receipts, although the balance at the bankers is certainly not large. It is to be regretted, I think, that the Council cannot report that anything is absolutely settled with regard to the future locality of the Institution; but I believe I may say, that the Government Surveyor has been permitted to put upon a proposed plan for the laying out of the Crown lands in this neighbourhood, a site for the Institution. It does not bind the Government to anything, and does not show that we shall get the site, but still it is a step gained. There is another point on which we may congratulate ourselves, namely, on the increased value and importance of the Papers which appear in the Journal. During the last two or three years they have very much improved in their character. This year, especially, there have been Papers of great interest, both on Naval and Military subjects. I think the publication in the Journal of one of the Essays from the Staff College, Sandhurst, a very good step, and if that practice is continued, it will, I think, be to our own benefit, and will also connect us with Sandhurst, which is desirable. There is another step the Council have taken, viz., with regard to instituting a Gold Medal, which the Members will doubtless highly approve of. This Medal is to be given annually for the best essay, alternately, upon Naval and Military subjects. A difficulty will arise in awarding the prize, and it depends entirely on the care which is taken in so doing, whether the experiment will prove successful. I think the Council cannot do better than associate themselves with the authorities at Sandhurst in that way, for it will tend still further to connect us with that Institution. I beg to move the adoption of the Report.

The Resolution having been seconded by Vice-Admiral Sir WALTER TARLETON, was put from the Chair and was carried unanimously.

V. The names of the eight Members retiring by rotation from the Council were read as follows:

Vice-Admiral the Right Hon. Sir JOHN C. DALRYMPLE HAY, Bart., M.P. &c.
Major WILSON, R.E.
W. F. HIGGINS, Esq.
Vice-Admiral RYDER.
Captain NOLLOTH, R.N.
Captain GOODENOUGH, R.N.
Major KNOLLYS.
Major-General F. EARDLEY-WILMOT R.A., F.R.S.

Colonel the Right Honourable Lord WAVENEY, F.R.S.—

The Resolution I have to propose is one which will require very little preface, and, in fact, we may almost anticipate it by the feelings of the Meeting:—

"That the thanks of this Meeting be given to the Members who retire from the Council by rotation."

Before I proceed, I beg to express my sense of the additional value that the Members of the Council have given to their services by the step that has been taken in offering a Gold Medal for competition. It appears to me to have this special value, that it will be a Gold Medal for either service, given to officers who have served,

or may have to serve, and who are aware of the difficulties that beset the combination of our forces in this country. Further, I have to move, "That the following Members be elected to fill the vacancies, viz.:

Vice-Admiral Sir J. C. D. Hay, Bart., M.P. Major C. W. Wilson, R.E. W. F. Higgins, Esq. Lieut.-Col. Lord Wm. F. Seymour.	For Re-election.	Admiral Sir Henry J. Codrington, K.C.B. Vice-Admiral Sir J. W. Tarleton, K.C.B. Captain Mayne, C.B., R.N. Colonel the Hon. F. Thesiger, C.B., A.D.C.

"And that the following names be adopted from which vacancies, in the event of their occurring, may be filled", viz.:—

Major-General Sir Richard Wilbraham, K.C.B.	Rear-Admiral Frederick Campbell.
Colonel Sir W. Henry R. Green, C.B., K.C.S.I.	Major-General J. L. Vaughan. C.B. Lieutenant-Colonel Aikman, C.C. Major Crossman, R.E."

Captain Hoseason, R.N.—

It is with much pleasure that I rise to second the motion, and I feel that I should be failing in my duty if I did not say a few words to those gentlemen who have taken so laborious a charge on their hands, and who are now retiring from the Council. Every one who looks at the excellent Papers that have been read, must know that we are indebted to the Members of the Council, not only for the selection of the various subjects, but also of the people to write them; the Members who are about to retire, must feel therefore that indirectly they have been the source of communicating very valuable information to our profession. I therefore beg to second the motion which the Noble Lord has proposed.

The Resolution was then put from the Chair, and was carried unanimously.

VI. Admiral Sir Henry Codrington, K.C.B.—

Very few words are required for a Resolution of this kind. I have to propose—

"That the thanks of this Meeting be given to the Auditors for their valuable services, and that the following gentlemen be elected for the ensuing year:—

T. G. Ridgway, Esq., for Re-election.
Thomas Smith, Esq.
Captain J. E. A. Dolby."

The Meeting will I think feel that, however well our accounts have been kept (and they certainly have been well kept, and very successfully brought before us), something more is wanted, namely, that they shall be well audited. This duty has been well performed by these gentlemen, and it is due to them that we should thank them. I therefore have great pleasure in proposing that the thanks of this Meeting be given to the Auditors who have served us so well, and propose that they be elected Auditors for the ensuing year.

The Resolution having been seconded by General Craufurd, was put from the Chair, and was carried unanimously

The CHAIRMAN—

Gentlemen, we have heard to day that it is the intention of the Council,—and it has been submitted to the Meeting,—to grant annually a Gold Medal. That Resolution appears to have received approval from all here, and I am sure it does not require any words from me to recommend it. I believe that nothing will add so much to the interests of this Institution, and so much to the character of the papers, and to the credit of those gentlemen who will have the honour of receiving that Medal, as the step which has been now taken. The subject for the Gold Medal Essay for this year is as follows, viz.:—"On the best mode of providing Recruits, and forming Reserves, for the British Army; taking into consideration its varied duties in peace and war."

The Chair having been taken by Colonel STEPHENSON, Chairman of the Council—

Sir WILLIAM CODRINGTON said—

I beg to propose that the thanks of this Meeting be given to Sir Alexander Milne for his kindness in attending here to-day and taking the Chair at our Anniversary Meeting. We have generally succeeded at our Annual Meetings in obtaining the attendance of one of the Cabinet Ministers connected either with the Army or the Navy, to identify himself with the well-being of this Institution. Very possibly, on the present occasion, in consequence of the recent change in the Ministry and the pressure of public business on the First Lord of the Admiralty, we are favoured with the presence of one of the executive officers of the Navy. I am sure that we thank any officer of his high rank, who takes an interest in the Institution. It has won its way by sheer work, that is to say by doing that which is of great consequence to the profession, namely, by free discussion on all subjects, both naval and military, —sometimes, perhaps, a little disagreeable to the Government,—but in no case, I believe, over-stepping the fair bounds of discussion. That is a very great point to be maintained, and every person who comes here to lecture should feel at perfect liberty to give his opinion—even though differing with the authorities—so long as it is done in a gentlemanly and officer-like manner. I need not detain this Meeting except to say, that we hope Sir Alexander Milne represents the head of the Navy as taking an interest in this Institution. I have no doubt that he, in his position as one of the Admiralty, will echo my feeling, namely, success to the Institution. I beg to propose a vote of thanks to Sir Alexander Milne.

Sir JOHN HAY.

Mr. Chairman, my Lords, and Gentlemen, I rise to second the Resolution which has just been proposed, and I do so with great pleasure. My gallant friend will remember that we cannot always have Cabinet Ministers to fulfil the function which has been so ably performed by Sir Alexander Milne to-day; and I venture to say that there is a feeling in this Institution, that however glad we may be to see distinguished Ministers of State here, we are equally glad, and quite as proud of our profession, when we see here distinguished officers like the gallant General who has proposed the resolution, who has distinguished himself in the field, or my equally distinguished friend, Sir Alexander Milne, who at sea and in the administration of this country, has shown what the officers of the Army and Navy can do, both in civil life and on active service. I am quite sure that he will speak also on behalf of my Right Honourable friend, Mr. Ward Hunt, in stating that the practical information (derived from Papers and discussions) afforded to the Government by this Institution, will be gratefully received by him. I therefore second my honourable and gallant friend in proposing a vote of thanks to Sir Alexander Milne for the way in which he has performed his duty here to-day; and I trust that he, in the Administration, will do his best to get that site which the gallant general (Sir Alexander Hamilton-Gordon) has said is already proposed on certain plans, for submission to her Majesty's Government.

The Resolution was then put from the Chair and was carried with acclamation.

SIR ALEXANDER MILNE—

My Lords and Gentlemen, I beg to thank you for the honour you have done me in according me a vote of thanks. I can only say that I am exceedingly grateful to the Council for having done me the honour of asking me to preside on this occasion. I accepted that invitation with the greatest pleasure; because, though I have not been participating as an active Member in this Institution, yet it is one that I have for years advocated as one of the most useful and practical for both Services. I have read with great attention, and with much interest, the valuable Journals which are published here. They contain matters of public interest both for the Army and Navy, as well as for civil life, and I can certainly concur in all that has been said to-day about our being under a deep obligation to the authors of those Papers for the address which they have displayed, and for the ability with which they have written them. But the usefulness of this Establishment is not confined to the discussions which take place here. I agree in every word which the gallant General said with regard to free discussion. I think it is for the interest of our professions that those who come here should clearly and explicitly state their views in that straightforward manner which cannot be objectionable to any Government. Besides the privilege of the Lectures, Members of this Institution have access to what is perhaps the finest professional library in the country. It is a great credit to the Members of the Council, and to those who have passed years in the discharge of their duties here, that this Establishment has been raised to the position which it now holds, that it has the finest library in the country, that it receives from foreign nations their principal works, and that both the War Office and the Admiralty are ready to come forward to render such assistance as they can in the way of books and charts. There is another way in which this Institution exercises a widespread influence. I believe that the Papers published here, have great influence in our respective professions; and I find that the junior officers of the Fleet have themselves established at Portsmouth a professional association founded on the principles of the Royal United Service Institution. They have united together for the purpose of discussing matters connected with the Service, and have published journals in the same manner as this Institution has done. But they have gone further—they have not yet come to a Gold Medal—but even in their infancy they offered a prize of £50 for the best Essay on Naval Evolutions and Naval Tactics. I think their having taken this step so creditable to those young men, that I take this opportunity of mentioning the subject with great pleasure and satisfaction. Thirteen Essays were sent in, and I was asked, in conjunction with Sir Cooper Key and Admiral Ryder, to decide which was the best. After considerable labour and time, we found that the Essay written by Lieut. Noel of the Navy, now serving in the "Active," on the coast of Africa, merited the prize, and it has accordingly been awarded to that officer. I have pleasure in mentioning that, because the Essay, which is now printed, does him great credit; and I also take the opportunity of referring to the subject as showing the influence that this Institution has over the professional officers of the Navy, and I believe of the Army also. I have to return you thanks for the compliment paid to me, and to assure you that my desire and my anxiety have been to forward the interests of our respective professions, and also to do all I could for this Institution. Before I resume my seat, I should allude in a few words to some changes which appear to have taken place. We have to regret the loss of two distinguished officers—one of the Navy and one of the Army. I think it would be unbecoming on my part in returning thanks for the honour you have done me, if I did not express a word of regret in your name for the loss of Admiral the Earl of Hardwicke, who was a Vice-Patron, and also of a personal friend of my own, well known to you all, General Fox, late Colonel of the 57th Regiment.

I trust that you will accept my thanks for the honour you have done me.

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P. Q. R., £1

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WHO JOINED THE INSTITUTION BETWEEN THE 26TH JUNE AND 31ST DECEMBER, 1873.

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Wilson, Belford R., Sub-Lieut. 13th Hussars.
Wood, Hon. F. L., Capt. R.N.
Douglas, Charles, Colonel R.A.
Bray, G. F. C., Lieut.-Col. 96th Regt.
Startin, R. F. P., Lieut. 10th Hussars.
Walker, H. Chesshyre, Lieut. R.A.
Boyd, Archd. D., Capt. 1st Roy. E. Middlesex Mil.
Arthur, Albert F., Midshipman R.N.
Sanderson, Patrick, Capt. 2nd Rl. N. B. Dragoons.
Brown, W. E., Lieut. 15th Regt.
Sapiehа, J. P. A. Prince, Lieut. 5th Dragoon Guards.
Armstrong, Sir Alexander, K.C.B., M.D., LL.D., F.R.S., &c.
Gloag, A. R., Colonel R.A.
Vyse, E. Howard, Colonel 3rd Hussars.
Beamish, Caulfield F., Captain late 45th Regt.
Lumsden, P. S., C.B., C.S.I., Col. Bengal Staff Corps.
Currie, Wm., of Linthill, Lieut. late Edin. Militia.
Crawford, Alex. de C., Lieut. R.N.

ANNUAL.

Cope, Sir Wm. H. Bart., late Lieut. Rifle Brigade.
Johnston, Alex. Campbell, Esq., late Govr. Hong Kong.
Crookshank, Arthur, Capt. Bengal Staff Corps.
Bradshaw, R. A., Captain R.N.
Bradshaw, F. Boyd, Lieut. 13th Regt.
Wace, R., Lieut. R.A.
MacFarlan, D., Lieut.-Col. R.H.A.
Brunel, Alfred, Lieut.-Col. Canadian Active Mil.
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Loch, William, Capt. 19th Bengal Cav.
Eyre, F. V., Major R.A.
Milner, Joseph, Midshipman R.N.
Ross, of Bladensburg, J. F. G., Lieut. Coldstream Guards.
Samson, A. M. W., Capt. 1st W. I. Regt.
Woods, J. A., Major h. p. Madras Army.
Oldfield, Geo. T., Capt. Roy. Lond. Mil.
Hutton, C. M., Sub-Lieut. 52nd Regt.
Hardtman-Berkeley, J. H., Lieut. 83rd Regt.
Wirgman, Theodore, Colonel late 6th Dragoons.
Lazenby, James, Major 100th Regt.
Stawell, Geo. D., Lieut. 11th Regt.
Walkey, R., Captain R.A.
Neilson, W. M., Lieut.-Col. 25th Lanark R.V.
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Scott, Geo. T., Lieut. 2nd Royal N.B. Dragoons.
Alexander, Hon. W. P., Lieut. 2nd Rl. N.B Dragoons.
Farquhar, F. G., Capt. 2nd Royal N.B. Dragoons.
Henry, J. L. V., Lieut. 2nd Royal N.B. Dragoons.
Frimstone, W. F., Lieut. 2nd Royal N.B. Dragoons.
Doherty, Chas. W O., Lieut. 2nd Royal N.B. Dragoons.
Russell, Hon. Geo. W. G., Lieut. 9th Royal Lancers.
Moore, John, Lieut. 6th Dragoon Gds.
McMahon, Alex. R., Lieut.-Col. Madras Staff Corps.
Huntingford, E. W., Lieut. 1st West India Regt.
Churchill, Lord E. S., Lieut. Isle of W. Militia.
Prior, H. Wallis, Lieut. 81st Regt.
Twemlow, Edw. D'O, Capt. R.E.
Davis, John, Capt. 2nd Surrey Mil.

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Johnson, H. J., Lieut. 80th Regt.
Thurlow, E. H., Lieut. 60th Rifles.
Mortimer, C. L., Lieut. 7th Rl. Fusiliers.
Borton, A. C., Lieut. 13th Regt.
Wavell, A. G. Lieut. 9th Regt.
Grogan, E. G., Lieut. 42nd Highlanders.
Rickards, A. W. L., Lieut. 1st Rl. Scots Regiment.
Randolph, Edmund, Lieut. 69th Regt.
St. Clair, J. L. C., Lt. 91st Highlanders.
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Dawes, Thomas, Capt. Beng. Staff Corps.
Duckett, W. M., Lieut. 21st Regt.
Kelly, J. G., Lieut. Bengal Staff Corps.
Cautley, George, Major-General Unatt.
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Blackett, E. U., Lieut. R.A.
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Prattent, F. M., Captain R.N.
Innes, Percival R., Lt.-Col. late Indian Army.
McCausland, M. F. H., Capt. R.A.
Mackenzie, John Kenneth, Lieut.-Col. Unatt.
White, David, Lieut. R.N.R., late Indian Navy.
Fawkes, Wilmot H., Lieut. R.N.
Gordon, C. S. S. Evans, Col., Gov. R.V. Hospital.
Leake, H., Capt. East York Mil., late 70th Regt.
Harvey, E., Capt. R.E.

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